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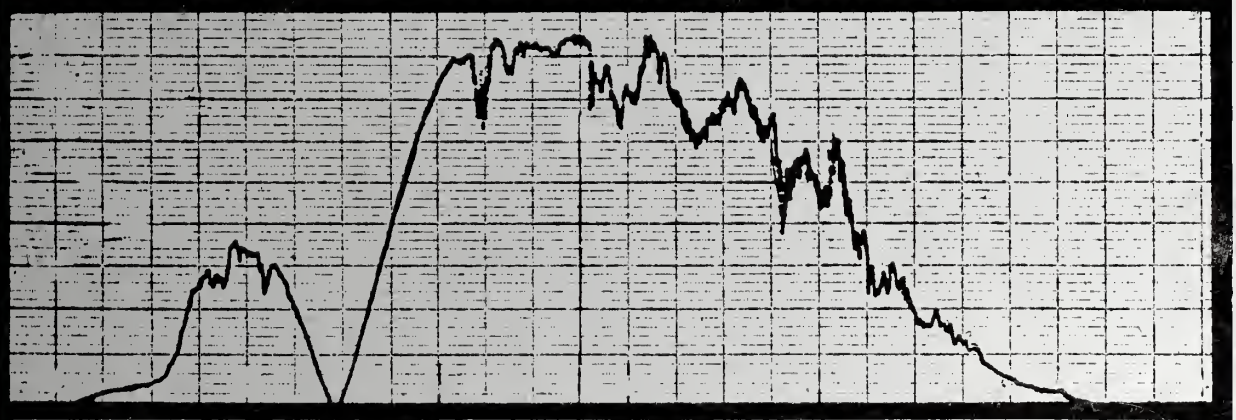

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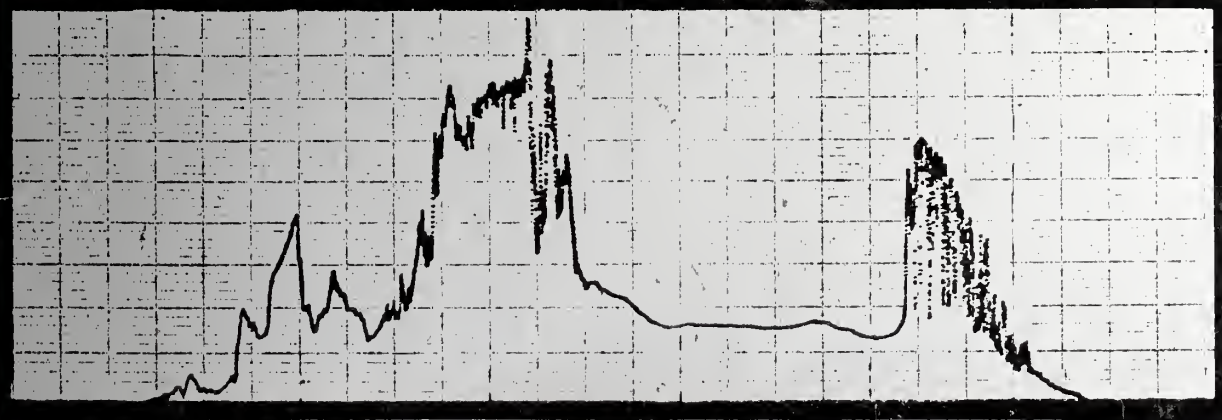

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COVER

Reproduced on the cover are strip chart records of solar radiation. The upper curve illustrates a clear day record and the lower curve was taken on a partially cloudy day. The center chart records the total eclipse on February 26, 1979.

The solar radiation data base contained in this 1980 edition is a summary of 32,425 daily strip charts recorded at 30 Montana stations between January, 1977 and December, 1980.

MONTANA SOLAR DATA MANUAL

May 1981

compiled by

Charless W. Fowlkes, Ph.D., P.E.

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Bozeman, MT 59715

supported by

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ALTERNATIVE RENEWABLE ENERGY SOURCES PROGRAM
32 S. Ewing
Helena, MT 59620

John Orndorff, Bureau Chief

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142-801 (1980)

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The volunteered assistance of over 50 Montana high school science teachers in maintaining the solar measurement instruments is crucial to the success of this program. Their names are listed on the following pages in this report and their many contributions are gratefully acknowledged.

Several members of the staff at Fowlkes Engineering have contributed to this solar measurement program and the Data Manual. Sharon Kleingartner and Pat Sullivan have carefully logged and organized strip chart records for over 40,000 data days. Sharon is acknowledged for her important role in entering the solar radiation data into the computer for processing. Carlos Lozano, Kellee Crisafulli and Ross Nelson have written numerous computer programs to process and verify the solar data. Jody Martinson typed this Manual and made editorial corrections.

The quality of the solar measurement program has benefited from the guidance of expert consultants. John Yellott has provided continuing advice concerning the accuracy of our measuring instruments since the beginning of the program. Douglas Hoyt of NOAA provided us with computer codes to calculate theoretical clear day solar radiation to improve the accuracy of the data. John Drumheller and Larry Kirkpatrick reviewed the "Handbook of Solar Energy Experiments", a document that was distributed to the high school volunteers. Joe Caprio, Montana State Climatologist, is acknowledged for providing us with the climatological data in this Manual from his extensive files. Mark McKinstry developed and verified the simplified f-chart design procedure appearing in Appendix IV of this edition. Ray Bahm has recommended methods to identify typical meteorological years from the data base. Roland Hulstrom of S.E.R.I. and Paul Berdahl of L.B.L. have contributed to the program.

STATIONS WITH CONTINUOUS RECORDERS

Location	School	Volunteer	Year
Anaconda	Anaconda	Mike Knutson	1979-81
		Tom Facey	1978-79
Billings	Billings Sr. H.S.	Mike Jablin	1977-81
Bozeman	Bozeman Sr. H.S.	Roscoe Montgomery	1977-81
Browning	Browning H.S.	Jim Prestbo	1977-81
Butte	Butte H.S.	John Giop	1978-81
Choteau	Choteau H.S.	Norman Kamrud	1978-81
Colstrip	Colstrip H.S.	Kelly Taylor	1979-81
		Dave Bowser	1977-79
Dillon	Beaverhead Co. H.S.	William Mular	1977-81
Ennis	Madison Val. Cons. H.S.	Jay Willett	1979-81
		Orville Hess	1978-79
Fort Benton	Fort Benton H.S.	A. Wm. Kindzerski	1979-81
		T. Daniel Gillen	1978-79
Glasgow	Glasgow H.S.	Norman Girard	1977-81
Glendive	Dawson Co. H.S.	Richard Lindgren	1978-81
Great Falls	C. M. Russell H.S.	W. Gary Shelden	1977-81
Hamilton	Hamilton H.S.	William Delaney	1977-81
Harlowton	Harlowton H.S.	Scott Dubbs	1980-81
		Milo Coladonato	1978-80
Havre	Havre H.S.	Marvin Gunnarson	1979-81
		Avon Whitehead	1977-79
Helena	Helena H.S.	Jim Haslip	1977-81
Jordan	Garfield Co. H.S.	Michael G. Mansfield	1979-81
Kalispell	Flathead H.S.	Gary Freebury	1977-81
Lewistown	Fergus H.S.	Howard Cooper	1977-81
Libby	Libby H.S.	Mike Funk	1977-81
Livingston	Park Sr. H.S.	Ben Williams	1978-81
Miles City	Custer Co. H.S.	Otto Neuhardt	1977-81
		John Potts	1977-81
Missoula	Hellgate H.S.	Norman Jacobson	1977-81
Plentywood	Plentywood H.S.	Harold Gackle	1978-81
Polson	Polson H.S.	Dan O'Brien	1979-81
		Ted Macy	1977-79
Red Lodge	Red Lodge H.S.	Bob Holmen	1978-81
Sidney	Sidney Sr. H.S.	Dan Scow	1980-81
		Gene Krueger	1978-80
Thompson Falls	Thompson Falls	Stuart Kilgore	1980-81
		Walter Clark	1978-79
West Yellowstone	West Yellowstone H.S.	Scott Carsley	1978-81

STATIONS WITH MANUAL RECORDERS

Location	School	Volunteer	Year
Baker	Baker H.S.	Max Mueller	1978-81
Big Timber	Sweetgrass Co. H.S.	Dick Willems	1977-78
Billings	Billings West H.S.	Gerald Raab	1978-81
Boulder	Jefferson H.S.	Mike Myrhow	1978-81
Broadus	Powder River Co. H.S.	Henry Eslinger	1977-81
Chester	Chester H.S.	Marvin Krook	1977-80
Chinook	Chinook H.S.	Gail Swant	1977-78
Circle	Circle H.S.	Robert Fitzgerald	1977-79
Columbus	Columbus H.S.	Waymoth Fitzgerald, Jr.	1977-78
Conrad	Conrad H.S.	James Guthrie	1978-80
Culbertson	Culbertson H.S.	Larry Hyslop	1978-79
Deer Lodge	Powell Co. H.S.	Gary Swant	1977-80
Ekalaka	Carter Co. H.S.	Pat Vaskey Jane Frye	1979-81 1977-79
Eureka	Lincoln Co. H.S.	Neil W. Nelson C. W. Calvert	1979-80 1979
Forsyth	Forsyth H.S.	Eli Urbaniak	1978-79
Great Falls	East Jr. H.S.	John Chase	1979
Hardin	Hardin H.S.	Bonnie Pluhar Roland Croghan	1978 1977-78
Harlem	Harlem H.S.	G. Daniel McNeill	1978-79
Hobson	Hobson H.S.	Rick McIntyre	1977-81
Malta	Malta H.S.	Steve Schumacher Jeffrey Bredeson	1978-81 1977-78
Missoula	Sentinel H.S.	Lyle Leischner Ronald Perrin	1979-81 1978-79
Roundup	Roundup H.S.	Jim Schladweiler	1977-81
Scobey	Scobey H.S.	Dee Black	1978-79
Superior	Superior H.S.	Clark Conrow	1977-79
Townsend	Broadwater Co. H.S.	William Alley	1977-81
Whitefish	Whitefish H.S.	Bruce Tannohill	1978-81
White Sulphur Springs	Wh. Sulph. Spgs. H.S.	Ken Marks Connie Perkins	1978-81 1977-78
Winnett	Winnett H.S.	Frank Witter	1977-78
Wolf Point	Wolf Point H.S.	Arthur Sikkink	1977-80

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I. REVIEW OF DATA BASES FOR SOLAR DESIGN

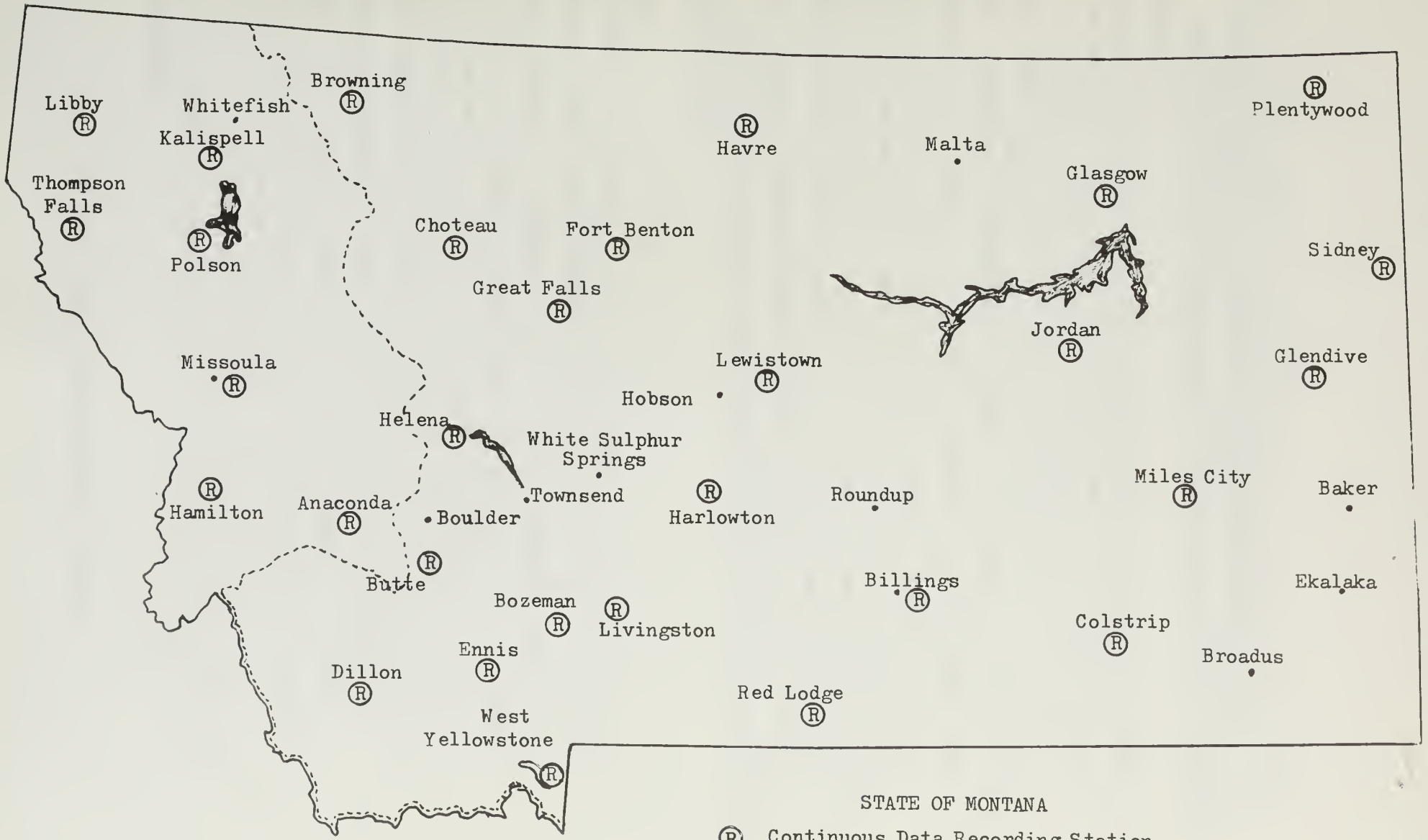
Introduction

The design of a solar conversion system involves consideration of a number of factors including: solar radiation available at the site, climatology of the site (terperatures, wind), availability of conventional energy, amount and quality of heat required, economics, taxes, etc. A sound climatological data base covering at least 40 years is available for most locations in Montana. Information on taxes, economics and conventional energy costs are available through established government and private institutions. Design procedures for estimating heat load and solar system performance are available in the appropriate technical literatures. A user oriented, simplified design procedure is included in this Manual. Long-term average solar radiation data is, unfortunately, not available at many locations in Montana. It is this area that is addressed by the Montana Solar Data Manual.

SIMM Solar Data

Early in 1977 the SIMM program (Solar Insolation Measurement, Montana) was initiated by Fowlkes Engineering under a grant from the Alternative Renewable Energy Sources Program of the Montana Department of Natural Resources and Conservation. Twenty instruments to measure solar radiation were sited across Montana during 1977 and an additional ten instruments were sited early in 1978. The map on the following page identifies the locations of the stations. The front cover of the Montana Solar Data Manual reproduces three examples of daily solar radiation records; over 40,000 days of data have been collected at this point. The overall goal of this program is to develop a solar radiation data base for use by solar designers. The results of the first four years' measurements are presented in this Manual. The accuracy of these results are discussed in Appendix III.

The solar radiation values presented in this Manual were all measured on a surface tilted 60° up from the horizontal and facing due south. This angle was chosen because it is representative of "typical" solar collector


Libby
Whitefish
Browning
Kalispell
Havre
Malta
Plentywood
Glasgow
Thompson Falls
Polson
Choteau
Fort Benton
Great Falls
Sidney
Jordan
Missoula
Lewistown
Glendive
Hobson
Helena
White Sulphur Springs
Townsend
Miles City
Baker
Hamilton
Anaconda
Boulder
Harlowton
Roundup
Billings
Ekalaka
Butte
Bozeman
Livingston
Colstrip
Ennis
Broadus
Dillon
Red Lodge
West Yellowstone
STATE OF MONTANA
Continuous Data Recording Station
Manual Data Station
Continental Divide

orientation used in Montana for collecting heat in the winter. This data can, consequently, be applied directly to many collector applications which improves the effective accuracy of this data base. The Manual contains procedures to convert this data to other tilt angles. Most of the locations covered in this Manual have no other source of measured solar radiation.

The main limitation to the use of the solar data in this Manual is the relatively short time period (three to four years) represented. There is no simple way at this time to assess how "typical" these values are. The designer can compare the four years' data given in the Manual for variability. He can also transform historical SOLMET horizontal data for Great Falls or Glasgow onto a 60° tilted surface and compare these values to average SIMM data for these stations. As the SIMM data base increases, the statistical confidence will naturally increase. For the time being, the designer must allow for a reasonable tolerance band in his design due to the absence of better alternatives.

SOLMET Solar Data

The National Climatic Center, Asheville, North Carolina, has archived historical solar radiation data for two locations in Montana: Great Falls and Glasgow. This data has been recently rehabilitated to an accuracy level of $\pm$ 5% and is part of the SOLMET data base. This data is available in tables as well as computer readable tapes. Also available in the SOLMET data base are derived solar radiations for Billings, Cut Bank, Dillon, Helena, Lewistown, Miles City and Missoula. The data for these locations is estimated from cloud cover observations and its accuracy is about $\pm$ 13%.

All SOLMET solar data is for radiation on a horizontal surface. Solar collector surfaces in Montana will normally be tilted from 45° to 90° up from horizontal, thus the SOLMET data cannot be used directly but must be converted to the appropriate tilt angle. There are several sources of error when using horizontal solar data which the designer should recognize: (1) The horizontal radiation data itself will tend to be less accurate in the winter due to the low altitude of the sun relative to a horizontal surface (cosine error) and possible temperature effects on the calibration factor; (2) Reflections from the snow will affect the total

II. GUIDE TO THE DATA TABLES

System of Units

Data in the Montana Solar Data Manual is tabulated using metric units. Earlier solar design books and articles will probably utilize conventional engineering units but most technical journals now require the use of metric or SI units. The units in this Manual will, therefore, be compatible with current and future technical literature.

The SI unit for energy is the Joule (1 Joule = 1 Watt-second). We have used the kilowatt-hour (kWh) for energy and kilowatt-hour per square meter (kWh/m^2 or KWH/SM) for energy-density. This convention is widely used for solar radiation. A table of conversion factors useful for solar design is included in Appendix V of this Manual. ($317\ BTU\text{-}ft^{-2} = 1\ kWh\text{-}m^{-2}$)

Solar Data

The solar radiation data has been summarized in two formats: OVERALL MONTHLY AVERAGE and ANNUAL MONTHLY AVERAGE. The primary quantity is the Daily Average. This quantity is calculated by adding together the measured daily energy density (in kilowatt hours per square meter) for each day in the period and dividing by the number of days in the averaging period.

The Table of Overall Monthly Averages summarizes all radiation data that has been measured at each station since the beginning of the SIMM program. The monthly average radiation per day is listed for each year. These values have been averaged for all available years and the average listed in the bottom line of each station table. These average values are thus the best current answer to the question, "What is the typical radiation at that station?". For those cases where there has been considerable missing data, we have inserted a suggested value for overall monthly average. These inserted values are flagged by parentheses.

A solar collector will convert only a portion of the incident solar radiation into useful heat; usually around 25% in winters and 50% in summers, based on daily total radiation. A particular collector will have a "threshold value" of radiation intensity above which it can operate efficiently. In a properly operating active system, the "threshold" is the point at which the circulation pump or fan turns on. In a passive system,

the "threshold" is the point where the solar heat coming in exceeds the heat loss of the collector. This threshold depends on many factors including the design of the collector (number of glazings, absorptivity and insulation), the storage temperature, and the ambient air temperature and wind velocity. Typical values of this threshold would be 0.1 to 0.2 kW/m^2 for warm weather and 0.2 to 0.4 kW/m^2 for cold weather.

The Tables of Monthly Radiation (Section V) include average percentages of total energy above 12 thresholds. The average energy above a particular threshold is determined by multiplying the Daily Average Energy by the percentage corresponding to that threshold and dividing by 100.

Tilt Correction

The solar radiation values presented in this Manual were all measured on a surface tilted 60° up from the horizontal and facing due south. The user may want to know the expected radiation on a surface at some other tilt angle. To do this conversion, we have included a Table of Monthly Tilt Correction Factors in Section IV. This Table is based on a simple radiation model. The factors should be considered preliminary cr tentative until further data is available.

Manual Solar Data

In addition to the 30 continuous solar recording stations there are currently 12 manual solar recording stations. The transducer for the manual stations is essentially the same as the recording stations except that a meter is used in place of the strip chart recorder and the instrument is hand held.

The volunteers at the manual stations are requested to make at least one reading of the solar intensity at 60° tilt, facing south around noon each school day. The readings are sometimes taken by teachers and often by the high school students as a project. The data is recorded on a prepared data form and sent to Fowlkes Engineering each month for processing. Some of the volunteers take and record hourly readings during the school day. No data is taken on weekends or during the summer vacation.

We process the data by averaging all available hourly solar intensity

readings each month. These values are plotted against time along with the zero points representing sunrise and sunset. A curve is drawn through these points to produce an "average day" insolation curve. This curve is integrated and the result presented in the Manual Data Tables.

The accuracy of this manual data depends primarily on the care with which the readings were taken and, consequently, cannot be easily determined. The solar designer should compare the Manual Data with nearby continuous recording stations to judge its probable accuracy.

Missing Data

As you look through the Solar Data Tables you will note that there are some periods for which no data is listed. Data is missing near the beginning of the year in 1977 and 1978 because the program had only recently been funded and the instruments were not installed yet. There have been three cases of stolen or vandalized instruments causing several months of lost data. Some schools had remodeling projects and electrical power outages which interfered with the continuity of the data. There were two cases in which strip chart records became entangled with the janitor's power floor waxer and were lost. Some records have been lost because the recorder ran out of chart paper or malfunctioned and some data was lost in the mail. Questionable data due to snow-covered transducers or faulty electrical connections were thrown out. In Lewistown, the transducer is mounted on a 2-foot mast on the roof. During January, 1978 they had 2½ feet of snow and the hatchway to the roof was frozen shut; therefore, about two weeks of data were lost. Total lost data due to all causes was about 17% of the current data period of 39,000 data-days.

The solar data tables flag lost data with parentheses placed around the daily average. These parentheses indicate that at least one day of data was missing in the averaging period.

Totals and Cloudy Day Statistics

Cloudy Day Tables are included for each station. The first table shows total cloudy days for each month for each year in the data base. Annual totals as well as overall monthly averages are included. If there were less than 20 available data days during the month an asterisk (*) is

printed. If there are less than 240 annual data days an asterisk is used to flag the Total.

Tables of the occurrences of cloudy days for each station show the number of times each year a specified duration of cloudy days occurred. A cloudy day was defined as a day with a total energy density less than 1.5 $kWh/m^2/day$ (473 $BTU/ft^2/day$). It is assumed that most solar collectors would deliver no useful heat on these "cloudy" days. The Tables were compiled for both the total year and the heating season, defined as October 1 to May 21. The number of data-days available are shown in parentheses above each table.

EXAMPLE: To find the number of occurrences of "n" or more cloudy days, add the occurrences of "n" to all occurrences greater than "n". In Kalispell in 1978, for a sample of 353 days, there were 31 single cloudy days and 15 cloudy periods of two or more days. Helena in 1978, for a sample of 353 days, had 22 single cloudy days and 11 cloudy periods of two or more days. During the heating season in Helena there were only 18 single cloudy days and 10 periods of two or more cloudy days.

The Cloudy Day Statistics will be useful in determining an optimal thermal storage size for a given system. The designer should note the total number of data-days associated with each table. Stations with significant missing data days will have distorted cloudy day statistics. The designer must also take into account the limited time span (three to four years) of this data.

Climatological Data

Selected long-term average climatological data taken from National Weather Service records is reproduced in this Manual. For the convenience of the user, the tables are reproduced in metric as well as conventional engineering units. Included are monthly average temperatures; mean daily, maximum daily and minimum daily; monthly record high and record low. The average degree days for each month, base 18.3° C (65° F), are also listed. This data should be useful in estimating the heat requirements of new designs.

SECTION III

TABLES OF OVERALL MONTHLY AVERAGE RADIATION

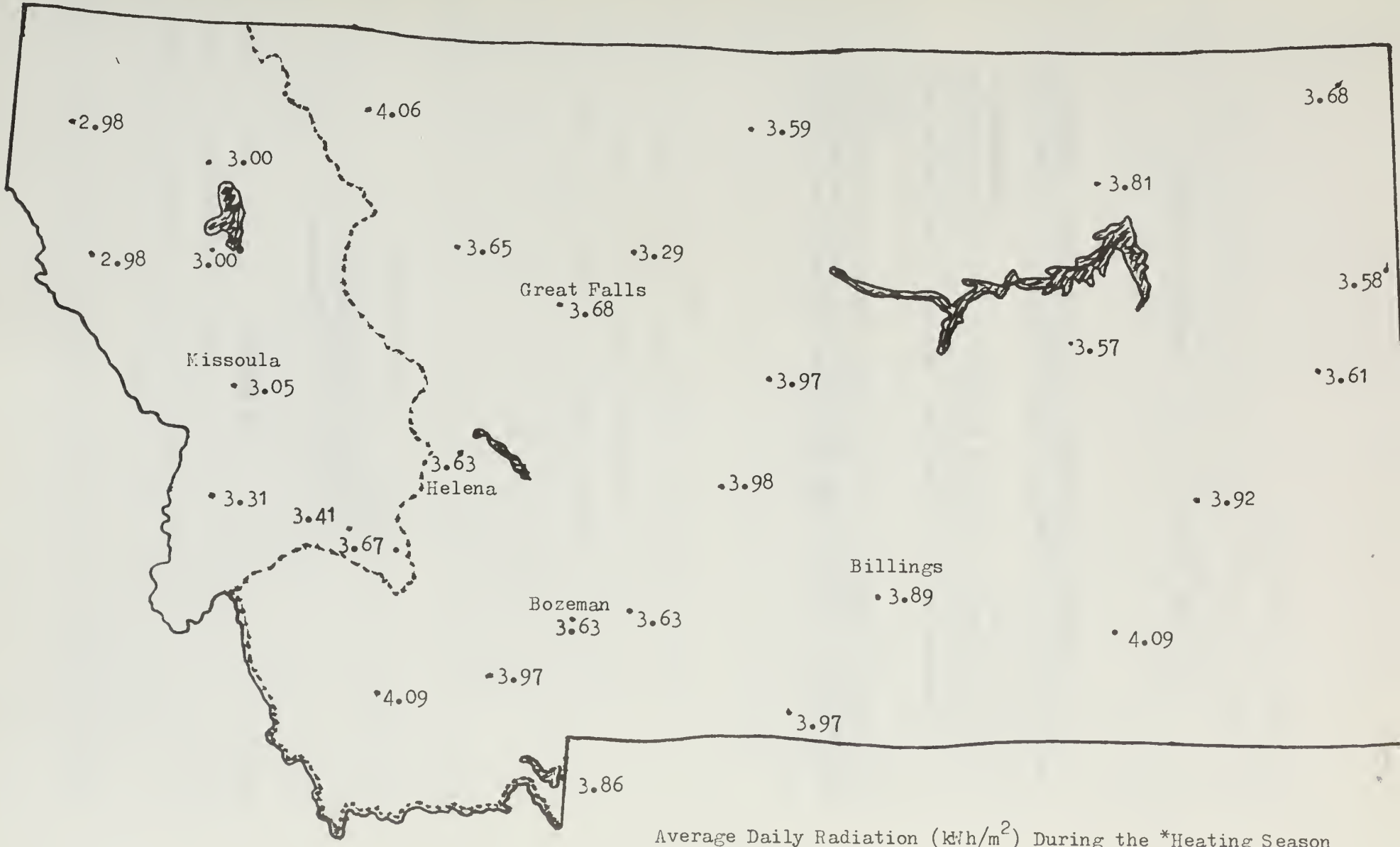
alphabetically by station

Note: These Tables summarize monthly average, daily total radiation over the entire monitoring period. An * appears by the monthly radiation if more than 10 days of data were missing during that month.

The bottom line of data for each station is the average of all data available. If there was inadequate data for a valid average, we inserted a suggested value and enclosed this value in parentheses.

This bottom line of average data is recommended for use in the simplified f-chart design procedure given in Appendix IV.

RADIATION (kWh/M2) x 317 = RADIATION (BTU/ft^2)



Average Daily Radiation (kWh/m^2) During the *Heating Season for 1977 Through 1980

*Heating Season = October 1 through April 30

ANACONDA AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1978	***	***	5.1*	3.9	3.3	4.2	4.8	4.4*	4.2	5.3	2.4	2.1	3.9*
1979	3.1	3.0	3.5*	4.0	4.4	4.2	4.6	3.9	4.7*	3.6	3.2	2.5	3.7
1980	2.8	3.0	3.6	4.5	3.3	3.9*	4.6	4.7	4.9*	4.3	2.8	2.1	3.6
AVG	3.0	3.0	4.1	4.2	3.7	4.1	4.7	4.3	4.6	4.4	2.8	2.3	3.7

BILLINGS AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1977	***	4.4	4.1	5.2	4.2	4.8	4.7	4.8	5.3	4.5	3.7*	3.1*	4.5
1978	2.7	3.6	4.9	3.9	3.6	4.7	4.2	5.1	4.7*	5.1*	3.4	3.0	4.0
1979	4.0	3.9	4.3	4.1	4.3	4.7	5.1	4.7	6.3	4.3	3.9	3.0	4.3
1980	3.3	3.3	4.0	5.2	4.7	4.8	5.2	4.7	4.6	4.5	2.8	1.9	4.1
AVG	3.3	3.8	4.4	4.6	4.2	4.7	4.8	4.8	5.2	4.6	3.5	2.7	4.2

BOZEMAN AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1977	3.0*	3.8	4.3	5.5	3.9	4.6	4.8	4.8	4.7	4.4	2.0	1.9	4.0
1978	2.5	3.8	5.0	4.0	3.8	4.5	4.7	5.0	4.5	5.2	2.9	2.4	4.1
1979	3.0	3.6	4.4	4.1	4.2	4.8	5.3	4.8	6.1	4.0	4.0	2.6	4.2
1980	3.0	2.6*	4.3	5.1	4.2	4.4	5.0	4.9	4.2	4.6	2.6	2.1	4.0
AVG	2.9	3.4	4.5	4.7	4.0	4.6	5.0	4.9	4.9	4.6	2.9	2.2	4.1

BROWNING AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1977	***	***	***	5.8	4.4	4.5	4.8	3.9*	4.1	4.2	3.0	2.0	4.0*
1978	3.1	4.1	4.1	3.7	4.0	5.2	4.7	4.8	4.9	4.6	4.8*	3.6*	4.4
1979	***	***	4.8*	5.1	4.4	5.1	4.8	***	5.8*	4.0	3.1*	***	4.7*
1980	***	***	4.4	5.3*	4.5	3.7*	***	***	4.8*	4.5	3.7*	2.3*	4.3*
AVG	3.1	(3.5)	4.4	4.9	4.3	4.6	4.7	(4.8)	4.9	4.3	3.6	2.6	4.3

BUTTE AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1977	4.6*	3.9	3.9	5.4	3.4	4.3	***	***	3.6*	4.5	3.6*	2.1	3.9*
1978	2.4	3.7	4.9	4.2	3.4*	***	***	***	***	4.2*	2.9	2.7	3.5*
1979	3.6	3.4	4.6	4.0	4.2	4.2	4.6*	***	6.0	3.9	3.9	2.7	4.0
1980	3.3	3.2	3.5	4.6	3.8	3.8	4.9	5.0	4.4	4.7	3.2	2.3	3.9
AVG	3.5	3.5	4.2	4.5	3.7	4.1	4.8	(4.8)	4.7	4.3	3.4	2.5	3.8

CHOTEAU AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1978	***	***	4.0*	4.3	4.0	4.9	4.6	4.9	4.3*	4.6	2.5	2.6	4.1
1979	3.3	3.5	4.7	4.4	4.3	4.6	5.2	4.8*	5.8	4.5	4.0	3.0	4.3
1980	3.2	3.0*	4.3	5.2	4.4	4.6	5.2	4.7*	4.3	4.4	3.1	1.3	3.9
AVG	3.2	3.2	4.3	4.6	4.2	4.7	5.0	4.8	4.8	4.5	3.2	2.3	4.1

COLSTRIP AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1977	***	4.3*	4.7	5.5	4.7	5.2*	***	***	***	***	***	***	4.9*
1978	***	***	4.9	4.3	4.1	4.7	4.6	5.2	5.9	5.0	3.5	2.5*	4.6
1979	***	3.6*	4.3	3.7	3.2*	4.2*	4.9*	4.2*	5.3*	4.6*	2.7*	2.9	3.7*
1980	2.9	2.8	4.2	4.8	4.5	5.0	5.3	6.4*	4.9	4.7	3.1	2.0	4.0
AVG	(3.3)	3.7	4.5	4.6	4.1	4.8	4.9	(5.0)	5.3	4.8	3.1	2.5	4.3

DILLON AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1977	4.5*	4.3	3.9	5.4	4.1	4.6	5.0	4.2	4.9	4.9	3.1	2.0	4.2
1978	2.4	4.4	5.4	4.6*	3.9	5.1	4.7	4.7	5.4*	5.9	3.8	3.3	4.5
1979	3.8	3.7	4.9	5.0	4.7	4.6	5.3	5.2	6.3	4.8	4.5*	3.3	4.7
1980	3.4	3.9	4.2	5.1	4.3	4.6	5.4	5.6*	4.9	4.6	3.2	2.6	4.3
AVG	3.5	4.1	4.6	5.0	4.3	4.7	5.1	4.9	5.4	5.1	3.6	2.8	4.4

ENNIS AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1978	***	4.9*	5.2	4.5	4.0	4.6	3.9*	***	6.4*	5.3	2.6	2.6	4.3*
1979	3.5	3.4	4.9	4.1	4.1	4.6	4.9	4.6	6.1	4.4	4.1	2.8	4.3
1980	3.4	3.3	3.9*	5.3*	4.0	4.4	4.2*	4.6	4.1	***	***	***	4.1*
AVG	3.4	3.9	4.7	4.7	4.0	4.5	4.3	4.6	(5.2)	4.9	3.4	2.6	4.2

FORT BENTON AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1978	***	3.9*	4.3	3.6	3.5	4.8*	5.5*	5.2	4.1*	4.3	2.8*	1.8	3.9*
1979	2.7	3.2	4.2	3.8	3.8	4.6	4.7	5.1	5.6	3.9	2.9	2.2	3.9
1980	2.4	2.9*	3.8	4.9	4.5	4.7	5.5	4.8	4.4	4.0	2.5	1.4	3.9
AVG	2.6	3.3	4.1	4.1	3.9	4.7	5.2	5.0	4.7	4.1	2.7	1.8	3.9

GLASGOW AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1977	3.4*	3.9	4.5	5.5	4.6	4.5	4.9*	4.2	3.6	4.3	3.2	2.1	4.1
1978	3.3	3.8	4.5	3.8	4.3	5.0	5.1	5.1	5.1	4.9	3.0	2.9	4.2
1979	3.5	3.9	5.2	4.2*	4.2	5.4	5.2*	5.2	5.7	4.4	3.0	2.5	4.3
1980	3.0	4.0	4.4	5.4	5.5	5.2	5.4	4.6	4.4	4.3	3.2	2.2	4.3
AVG	3.3	3.9	4.6	4.7	4.6	5.0	5.2	4.8	4.7	4.5	3.1	2.4	4.2

GLENDIVE AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1977	3.3*	4.0	4.3	5.3	4.9	4.7	***	4.2	3.8	4.1	3.0	2.2	4.1
1978	3.1	3.2	4.1	3.6	3.6	4.7	4.7	6.2*	5.5	4.1	2.6*	***	4.0
1979	***	3.7*	4.0*	3.6	4.5	4.8	4.8	4.8	5.2	3.1*	***	***	4.6*
1980	3.5*	2.9*	4.7	5.0	5.4	4.9*	4.9	4.3*	***	3.5*	3.1	1.9	4.1
AVG	3.3	3.5	4.3	4.4	4.6	4.8	4.8	4.9	4.9	3.7	2.9	2.1	4.2

GREAT FALLS AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1977	1.5*	4.0	4.2	5.2	4.3	4.9	5.1	4.4	4.4	4.1	3.3	3.0	4.3
1978	3.0	3.8	4.2	4.2	4.1	5.0	4.8	5.2	4.5	4.4	3.0	2.8	4.1
1979	3.3	3.5	4.4	3.9	4.2	4.8	5.2	5.4	5.9	4.1	3.7	2.9	4.3
1980	2.9	2.9	4.2	5.2	4.7	5.1	5.3	4.7	4.4	4.2	2.9	1.5	4.0
AVG	2.7	3.5	4.2	4.6	4.3	4.9	5.1	5.0	4.8	4.2	3.2	2.6	4.2

HAMILTON AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1977	***	***	3.5*	5.2	3.8	4.5	4.2	***	3.2*	4.1	2.5	1.5	3.7*
1978	1.5	3.0	4.4	4.2	3.1*	***	***	4.3*	3.6*	5.1	2.2	2.4	3.3*
1979	3.2	2.5	4.6	4.0	4.7	4.7	5.0	6.4*	5.8	3.9	3.3	1.8	4.0
1980	2.8	2.9	3.3	4.4	4.2	4.3	5.0*	5.1	4.1	4.6	2.8	2.1	3.7
AVG	2.5	2.8	4.0	4.5	4.0	4.5	4.7	(5.0)	4.1	4.4	2.7	1.9	3.7

HARLOWTON AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1977	3.2*	4.6	4.6	5.6	4.3	5.3*	4.8	4.7	4.9	4.5	2.6*	2.8	4.4
1978	3.2*	3.7	5.0	4.0	3.8	4.4*	4.5	5.2	4.6	***	***	***	4.3*
1979	4.9*	3.9	4.9*	***	4.2	4.7	5.6*	4.6*	6.0	4.4	3.7	3.1	4.4
1980	3.3	3.2	***	5.4*	4.5	4.5	5.2	4.7	5.0*	4.4	3.5	2.6*	4.2
AVG	(3.3)	3.8	4.8	(4.8)	4.2	4.7	5.0	4.8	5.1	4.4	3.2	2.8	4.3

HAVRE AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1977	***	4.2	4.6	5.5*	4.6	4.7	4.7	4.4	4.1	4.4	3.3	2.4	4.2
1978	2.8*	3.7	4.3	3.4	3.8	4.7	4.4	3.4*	4.6	4.5	2.8	2.1	3.8
1979	3.5	3.2*	4.9	3.7	4.5	***	***	4.2*	5.4	4.1	3.5	2.4	4.0
1980	2.8	3.2*	4.3	5.3	5.2	4.4	3.8	3.6	4.4	2.6*	2.7	1.8	3.7
AVG	3.0	3.6	4.5	4.5	4.5	4.6	4.3	3.9	4.6	3.9	3.1	2.2	3.9

HELENA AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1977	2.4	4.2	3.8	5.1	4.1	4.7	5.1*	4.8	4.5	4.5	3.1	2.3	4.0
1978	2.7	3.5	4.9	4.6	3.6	4.9	4.8	5.1	4.6	5.1	2.8	2.6	4.1
1979	3.7	3.4	4.7	4.3	4.4	4.6	4.8	4.9	5.7	4.1	3.6	2.7	4.2
1980	3.1	2.9	3.9*	5.1	4.0	3.4	3.0*	3.9*	5.1*	4.5	3.1	1.8	3.5
AVG	2.9	3.5	4.3	4.8	4.0	4.4	4.4	4.6	5.0	4.5	3.2	2.4	4.0

JORDAN AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1978	***	***	***	***	4.1	5.0	5.1	5.6	4.9	4.3	2.4	2.1	4.2*
1979	3.1	3.4	4.2	4.2	4.4	***	***	5.1*	6.0	4.4	3.4	2.4*	4.1
1980	3.4	3.7	4.7	5.5	5.1	4.5	4.9	5.8*	4.7	4.9	3.6	2.3	4.4
AVG	3.2	3.5	4.4	4.8	4.5	4.8	5.0	(5.2)	5.2	4.6	3.2	2.3	4.2

KALISPELL AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1977	***	2.8	3.0	5.0	3.9	4.7	4.0*	4.8	3.7	3.9	2.5	1.8	3.7
1978	1.6	2.8	4.3	3.8	3.7	4.9	4.7	4.2	3.6	4.7	2.3	2.0	3.6
1979	2.7	1.9	4.5	4.1	4.4	4.9	5.2	5.5	6.1	3.4	1.8	.7	3.8
1980	2.9	2.4*	3.5	4.7	4.1	4.2	4.8	4.8	4.3	4.2	1.7	1.1	3.6
AVG	2.4	2.5	3.8	4.4	4.0	4.7	4.7	4.8	4.4	4.0	2.1	1.4	3.7

LEWISTOWN AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1977	***	4.2	4.5	5.4	4.4	5.1	4.7*	4.3	4.7	4.4	3.0	2.9	4.3
1978	2.7*	3.7	5.1	4.0	4.0	4.9	4.4	***	4.5	4.9	2.9*	3.0*	4.2
1979	3.9	4.1	4.5	4.2	4.2	5.0	5.3	5.1	6.2	4.4	3.7	3.1	4.5
1980	3.1	3.9	4.0	5.5	4.8	4.6	5.2	4.9	4.3	4.5	3.3	2.1	4.2
AVG	3.2	4.0	4.5	4.8	4.3	4.9	4.9	4.8	4.9	4.5	3.2	2.8	4.3

LIBBY AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1977	***	3.3*	3.4	5.3	3.5	4.8	4.4*	5.6*	3.7	3.6	2.2*	4.1*	4.0*
1978	***	2.7*	3.8	3.4	3.6	4.8	4.5	3.8	3.2	4.1	2.0	1.6	3.4
1979	2.9*	1.7	4.5	3.9	4.6	4.9	4.9	5.4	5.4	3.4	1.3	.8	3.8
1980	2.3	1.6	3.1	4.4	3.7	4.0	4.8	4.4	3.8	3.2	1.6*	.9	3.3
AVG	2.6	2.3	3.7	4.3	3.9	4.6	4.7	4.8	4.0	3.6	1.8	1.9	3.6

LIVINGSTON AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1978	***	4.0*	4.7	4.2*	3.6	5.2*	4.7	5.1*	5.1*	4.7	4.0*	2.2*	4.4*
1979	3.1*	2.9*	4.4	4.0	5.3*	5.6*	5.2	***	***	***	3.4*	2.4	3.9*
1980	2.9	3.0*	4.0*	5.1	4.3	4.2*	5.0	5.2*	5.3*	4.0	2.9	1.8	3.8
AVG	3.0	3.3	4.3	4.4	4.4	5.0	5.0	5.2	5.2	4.4	3.4	2.2	4.0

MILESCITY AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1977	3.6*	4.3	4.5	5.7	4.6	5.1*	5.0*	4.5	4.5	4.5	3.1	2.3	4.3
1978	3.1	3.9	4.7	4.1	3.7	4.7	4.8	***	4.8*	4.6	3.1	3.0	4.0
1979	4.1	4.3	5.1	4.2	4.5	5.0	4.9*	5.0*	5.5	4.4	3.0	3.2	4.4
1980	3.2	3.4	4.2	5.1	4.9	4.8	5.1	4.6	4.8	4.4	***	2.0*	4.3
AVG	3.5	4.0	4.6	4.7	4.4	4.9	4.9	4.7	4.9	4.5	3.1	2.6	4.2

MISSOULA AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1977	2.8*	3.2	2.9	5.1	3.6	4.7	4.1	4.7	3.6	4.1	2.3	1.5*	3.7
1978	1.5	2.4	4.4	4.0	3.1	4.5	4.7	4.6	3.8	4.9	2.7	1.9	3.6
1979	2.7	2.0	4.3	3.7	4.4	4.6	5.1	5.0	5.9	3.7	2.4	1.3	3.8
1980	2.6	2.1	2.9	3.9	3.8	3.6	4.6	5.0	3.9	4.5	1.7	1.4	3.4
AVG	2.4	2.4	3.6	4.2	3.7	4.5	4.7	4.8	4.3	4.3	2.3	1.5	3.6

PLENTYWOOD AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1978	***	4.5*	4.9	3.6	3.9	4.8	4.7	5.0	4.5*	4.3	2.6	2.5	4.1
1979	3.7*	3.5	4.2	3.5	3.7	4.6	5.0	5.5	5.4	4.4	2.7	3.0	4.2
1980	3.3	4.2	4.3	5.3	5.5	4.7	5.2	4.8	4.4	4.3	3.4	2.2	4.3
AVG	3.5	4.1	4.4	4.1	4.4	4.8	5.0	5.1	4.8	4.3	2.9	2.5	4.2

FOLSOM AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1977	2.0*	2.8	3.0	5.2	4.0	4.7	4.5	5.0	4.0	4.1	2.3	1.6*	3.8
1978	1.3	2.8	4.7	4.2	3.5	4.8	5.0	4.7	3.8	4.8	2.2	1.8	3.6
1979	2.3*	2.3	4.6	3.9	4.5	***	***	4.6*	5.7	3.7	1.5	1.1	3.4
1980	2.4	2.3	3.4	4.5	4.1	4.4	5.0	4.9	4.2	4.1	1.5	1.3	3.5
AVG	2.0	2.5	3.9	4.4	4.0	4.6	4.8	4.8	4.4	4.2	1.9	1.5	3.6

REDLODGE AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1978	***	3.6*	4.8	3.4	3.6	3.9	4.3	4.7	4.7	5.2	3.4	3.2	4.1
1979	3.8	4.1	4.4	4.4	4.3	4.7	4.6	4.3	5.8	4.4	4.1	3.4	4.4
1980	3.3	3.7	4.2	5.3	4.0	4.6	4.4	4.2	4.5	4.8	3.3	2.6	4.1
AVG	3.6	3.8	4.5	4.3	4.0	4.4	4.5	4.4	5.0	4.8	3.6	3.0	4.2

SIDNEY AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1978	***	4.6*	4.7	3.4	3.7	4.0*	***	***	***	***	2.9*	2.1	3.6*
1979	3.5	3.5	4.7	4.1	4.0	4.5	4.6	4.9	5.7	4.2	2.8	2.8	4.1
1980	3.2	3.5	4.5*	***	***	4.6	4.5	4.1	4.2	4.6	3.2	2.3*	3.9
AVG	3.4	3.9	4.7	3.8	3.8	4.4	4.5	4.5	4.9	4.4	3.0	2.4	3.9

THOMPSON FALLS AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1978	***	2.2*	3.4	3.6	3.2	4.6	4.4	3.4*	***	4.5	2.0	1.4	3.3*
1979	2.9	1.9	4.4	3.9	4.1	4.7*	***	***	***	3.1*	***	***	3.6*
1980	4.0*	2.1	2.7	4.6	***	4.0*	4.6	4.6	4.0	3.9	1.5	.7	3.3
AVG	(3.1)	2.1	3.5	4.0	3.7	4.4	4.5	4.0	4.0	3.8	1.8	1.0	3.4

WEST YELLOWSTONE AVERAGE DAILY RADIATION (KWH/M2)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
1977	5.0*	5.2	3.9	5.2	3.6	4.6	4.8*	3.3*	4.8	5.4*	2.6*	2.1	4.2
1978	1.4*	3.3	4.8	4.2	3.8	4.6	4.6	***	5.8*	5.8	2.7	2.9	4.0
1979	3.7	2.9	5.1	5.3	4.9	4.6	5.1	4.5	6.1	4.3	2.3*	3.1*	4.5
1980	2.4	3.2	3.9	5.2	3.7	4.4	4.8	5.1	4.8*	4.6	2.9	2.1	3.9
AVG	3.1	3.6	4.4	5.0	4.0	4.5	4.8	4.3	5.4	5.0	2.6	2.5	4.2

SECTION IV

ASHRAE TABLES

and

TILT CORRECTION FACTORS

RADIATION (kWh/M2) x 317 = RADIATION (BTU/ft^2)

ASHRAE CLEAR DAY TABLES

48 Degrees North Latitude

DATE	SOLAR TIME AM	SOLAR TIME PM	SOLAR POSITION ALT	SOLAR POSITION AZM	BTUH/SQ. FT. TOTAL INSOLATION ON SURFACES NORMAL	HORIZ.	SOUTH FACING SURFACE ANGLE WITH HORIZ. 38	48	58	68	90
JAN 21	8	4	3.5	54.6	37	4	17	19	21	22	22
	9	3	11.0	42.6	185	46	120	132	140	145	139
	10	2	16.9	29.4	239	83	190	206	216	220	206
	11	1	20.7	15.1	261	107	231	249	260	263	243
	12		22.0	0.0	267	115	245	264	275	278	255
	SURFACE DAILY TOTALS				1710	596	1360	1478	1550	1578	1478
FEB 21	7	5	2.4	72.2	12	1	3	4	4	4	4
	8	4	11.6	60.5	188	49	95	102	105	106	96
	9	3	19.7	47.7	251	100	178	187	191	190	167
	10	2	26.2	33.3	278	139	240	251	255	251	217
	11	1	30.5	17.2	290	165	278	290	294	288	247
	12		32.0	0.0	293	173	291	304	307	301	258
	SURFACE DAILY TOTALS				2330	1080	1880	1972	2024	1978	1720
MAR 21	7	5	10.0	78.7	153	37	49	49	47	45	35
	8	4	19.5	66.8	236	96	131	132	129	122	96
	9	3	28.2	53.4	270	147	205	207	203	193	152
	10	2	35.4	37.8	287	187	263	266	261	248	195
	11	1	40.3	19.8	295	212	300	303	297	283	223
	12		42.0	0.0	298	220	312	315	309	294	232
	SURFACE DAILY TOTALS				2780	1578	2208	2228	2182	2074	1632
APR 21	6	6	8.6	97.8	108	27	13	9	8	7	5
	7	5	18.6	86.7	205	85	76	69	59	48	21
	8	4	28.5	74.9	247	142	149	141	129	113	69
	9	3	37.8	61.2	268	191	216	208	194	174	115
	10	2	45.8	44.6	280	228	268	260	245	223	152
	11	1	51.5	24.0	286	252	301	294	278	254	177
	12		53.6	0.0	288	260	313	305	289	264	185
	SURFACE DAILY TOTALS				3076	2106	2358	2266	2114	1902	1262
MAY 21	5	7	5.2	114.3	41	9	4	4	4	3	2
	6	6	14.7	103.7	162	61	27	16	15	13	10
	7	5	24.6	93.0	219	118	89	75	60	43	13
	8	4	34.7	81.6	248	171	156	142	123	101	45
	9	3	44.3	68.3	264	217	217	202	182	156	86
	10	2	53.0	51.3	274	252	265	251	229	200	120
	11	1	59.5	28.6	279	274	296	281	258	228	141
	12		62.0	0.0	280	281	306	292	269	238	149
	SURFACE DAILY TOTALS				3254	2482	2418	2234	2010	1728	982
JUN 21	5	7	7.9	116.5	77	21	9	9	8	7	5
	6	6	17.2	106.2	172	74	33	19	18	16	12
	7	5	27.0	95.8	220	129	93	77	59	39	15
	8	4	37.1	84.6	246	181	157	140	119	95	35
	9	3	46.9	71.6	261	225	216	198	175	147	74
	10	2	55.8	54.8	269	259	262	244	220	189	105
	11	1	62.7	31.2	274	280	291	273	248	216	126
	12		65.5	0.0	275	287	301	283	258	225	133
	SURFACE DAILY TOTALS				3312	2626	2420	2204	1950	1644	874
JUL 21	5	7	5.7	114.7	43	10	5	5	4	4	3
	6	6	15.2	104.1	156	62	28	18	16	15	11
	7	5	25.1	93.5	211	118	89	75	59	42	14
	8	4	35.1	82.1	240	171	154	140	121	99	43
	9	3	44.8	68.8	256	215	214	199	178	153	83
	10	2	53.5	51.9	266	250	261	246	224	195	116
	11	1	60.1	29.0	271	272	291	276	253	223	137
	12		62.6	0.0	272	279	301	286	263	232	144
	SURFACE DAILY TOTALS				3158	2474	2385	2200	1974	1694	956

DATE	SOLAR TIME AM	SOLAR TIME PM	SOLAR POSITION ALT	SOLAR POSITION AZM	BTUH/SQ. FT. TOTAL INSOLATION ON SURFACES NORMAL	HORIZ.	SOUTH FACING SURFACE ANGLE WITH HORIZ. 38	48	58	68	90
AUG 21	6	6	9.1	98.3	99	28	14	10	9	8	6
	7	5	19.1	87.2	190	85	75	67	58	47	20
	8	4	29.0	75.4	232	141	145	137	125	109	65
	9	3	38.4	61.8	254	189	210	201	187	168	110
	10	2	46.4	45.1	266	225	260	252	237	214	146
	11	1	52.2	24.3	272	248	293	285	268	244	169
	12		54.3	0.0	274	256	304	296	279	255	177
	SURFACE DAILY TOTALS				2898	2086	2300	2290	2046	1836	1208
SEP 21	7	5	10.0	78.7	131	35	44	44	43	40	31
	8	4	19.5	66.8	215	92	124	124	121	115	90
	9	3	28.2	53.4	251	142	196	197	193	183	143
	10	2	35.4	37.8	269	131	251	254	248	236	185
	11	1	40.3	19.8	278	205	287	289	284	269	212
	12		42.0	0.0	280	213	299	302	296	281	221
	SURFACE DAILY TOTALS				2568	1522	2102	2118	2070	1966	1546
OCT 21	7	5	2.0	71.9	4	0	1	1	1	1	1
	8	4	11.2	60.2	165	44	86	91	95	95	87
	9	3	19.3	47.4	233	94	167	176	180	178	157
	10	2	25.7	33.1	262	133	228	239	242	239	207
	11	1	30.0	17.1	274	157	266	277	281	276	237
	12		31.5	0.0	278	166	279	291	294	288	247
	SURFACE DAILY TOTALS				2154	1022	1774	1860	1890	1866	1626
NOV 21	8	4	3.6	54.7	36	5	17	19	21	22	22
	9	3	11.2	42.7	179	46	117	129	137	141	135
	10	2	17.1	29.5	233	83	186	202	212	215	201
	11	1	20.9	15.1	255	107	227	245	255	258	238
	12		22.2	0.0	261	115	241	259	270	272	250
	SURFACE DAILY TOTALS				1668	596	1336	1448	1518	1544	1442
DEC 21	9	3	8.0	40.9	140	27	87	98	105	110	109
	10	2	13.6	28.2	214	63	164	180	192	197	190
	11	1	17.3	14.4	242	86	207	226	239	244	231
	12		18.6	0.0	250	94	222	241	254	260	244
	SURFACE DAILY TOTALS				1444	446	1136	1250	1326	1364	1304

Note: To make these values correspond to the ASHRAE clear day model used in this Manual, multiply by a clearness factor of 1.05 for April through October, and 1.08 for the rest of the year (reflection from snow in winter).

317 BTUH/ft^2 = 1 kW/m^2

PRELIMINARY
TABLE OF MONTHLY TILT CORRECTION FACTORS

TILT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
90	.94	.87	.79	.69	.61	.57	.60	.69	.78	.87	.94	.96
85	.96	.91	.84	.75	.68	.66	.68	.75	.83	.91	.96	.99
80	.98	.94	.88	.81	.76	.73	.76	.81	.88	.94	.98	1.00
75	1.00	.96	.92	.87	.83	.81	.83	.87	.92	.96	1.00	1.01
70	1.00	.98	.95	.92	.89	.88	.89	.92	.95	.98	1.00	1.01
65	1.01	.99	.98	.96	.95	.94	.95	.96	.98	.99	1.01	1.01
60	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
55	.99	1.00	1.01	1.03	1.05	1.05	1.05	1.03	1.01	1.00	.99	.98
50	.97	.99	1.02	1.06	1.08	1.10	1.08	1.06	1.02	.99	.97	.96
45	.94	.98	1.02	1.07	1.12	1.13	1.12	1.07	1.02	.98	.94	.93
40	.91	.96	1.02	1.08	1.14	1.16	1.14	1.08	1.02	.96	.91	.90

This table contains monthly tilt correction factors to convert solar radiation values in the Tables (measured at a 60° tilt) onto surfaces having some tilt other than 60°. These factors are based on a simple radiation model and are thus approximate or preliminary. Improved factors will be given at a later date as data becomes available.

EXAMPLE: The measured average radiation from the Tables in February was 4.6 kWh/m^2 on a 60° tilted surface: What was the radiation on a 90° (vertical) surface?

Look in the Table above under <u>February</u> at a <u>Tilt</u> of 90°. The factor is 0.87. The radiation on the 90° surface is thus 0.87 x 4.6 or 4.0 kWh/m^2.

SECTION V

TABLES OF MONTHLY RADIATION BY YEAR

alphabetically by station

Note: The solar radiation values presented in these tables were all measured on a surface tilted 60° up from the horizontal and facing due south.

The solar data tables flag lost data with parentheses placed around the daily average. These parentheses indicate that at least one day of data was missing in the averaging period.

RADIATION (kWh/M2) x 317 = RADIATION (BTU/ft^2)

THIS STATION NOT INSTRUMENTED IN 1977

SOLAR RADIATION DATA for: ANACONDA,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB													
MAR	(5.05)	97	93	87	82	78	70	63	54	24	3	0	0
APR	(3.92)	91	78	68	56	45	37	30	21	11	2	0	0
MAY	3.26	83	65	47	39	33	26	21	16	4	0	0	0
JUN	(4.21)	91	83	71	61	50	37	26	12	2	0	0	0
JUL	(4.77)	93	85	79	67	59	50	40	28	12	2	1	0
AUG	(4.40)	95	90	83	74	64	53	48	30	14	0	0	0
SEP	4.19	88	75	69	62	54	46	40	29	21	7	1	0
OCT	(5.31)	97	94	88	83	77	67	59	48	34	16	1	0
NOV	(2.43)	81	60	47	40	35	29	22	16	9	0	0	0
DEC	(2.13)	83	63	54	44	34	24	17	9	1	0	0	0

SOLAR RADIATION DATA for: ANACONDA,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.13)	85	66	59	54	48	41	31	24	16	3	0	0
FEB	(3.00)	91	76	63	50	41	32	25	20	15	7	2	0
MAR	(3.52)	91	70	56	43	37	29	26	20	15	5	0	0
APR	3.97	93	78	67	52	42	34	25	17	12	3	0	0
MAY	4.43	93	82	72	60	48	38	31	18	6	1	0	0
JUN	(4.24)	91	79	69	60	49	35	26	15	4	0	0	0
JUL	4.57	92	83	76	66	56	47	33	23	8	0	0	0
AUG	3.85	88	78	70	58	51	42	30	19	6	1	0	0
SEP	(4.73)	97	91	85	76	64	53	40	31	17	5	0	0
OCT	3.62	89	75	65	59	52	43	36	27	20	6	1	0
NOV	(3.22)	88	76	69	65	58	51	40	28	16	1	0	0
DEC	2.47	88	76	67	61	51	40	26	16	4	2	0	0

SOLAR RADIATION DATA for: ANACONDA,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.77)	88	71	59	51	43	38	32	24	12	1	0	0
FEB	(2.98)	90	79	60	50	42	34	24	19	12	3	1	0
MAR	3.62	94	80	66	55	46	37	24	17	12	4	0	0
APR	(4.54)	93	84	75	67	57	45	36	27	17	2	1	0
MAY	(3.33)	83	69	59	49	38	30	23	17	8	0	0	0
JUN	(3.92)	92	80	67	57	42	30	22	14	4	0	0	0
JUL	(4.61)	94	82	75	66	59	49	36	24	3	0	0	0
AUG	(4.68)	95	88	82	73	63	51	39	25	11	1	0	0
SEP	(4.85)	95	89	83	76	66	59	50	38	24	2	0	0
OCT	4.32	89	80	76	69	64	57	46	36	23	6	0	0
NOV	(2.82)	85	69	61	57	48	42	34	26	15	2	0	0
DEC	2.13	78	67	57	46	36	29	20	13	5	1	0	0

SOLAR RADIATION DATA for: BILLINGS,MONTANA 1977

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB	(4.38)	86	80	76	71	65	60	51	41	27	7	0	0
MAR	(4.14)	91	80	72	65	57	48	38	30	17	4	1	0
APR	(5.20)	94	87	81	73	65	58	48	35	16	1	0	0
MAY	4.23	91	82	72	63	53	42	30	14	1	0	0	0
JUN	(4.76)	94	88	82	75	66	54	41	24	2	0	0	0
JUL	4.66	94	88	80	72	62	52	40	21	0	0	0	0
AUG	4.77	94	86	80	73	66	55	43	30	5	0	0	0
SEP	(5.25)	93	87	80	76	70	63	53	40	23	4	0	0
OCT	(4.46)	90	83	76	70	64	56	47	33	17	1	0	0
NOV	(3.73)	90	85	78	69	59	51	39	28	13	1	0	0
DEC	(3.13)	83	69	62	59	53	46	36	27	15	2	0	0

SOLAR RADIATION DATA for: BILLINGS,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	2.70	89	66	50	45	36	31	24	18	10	2	0	0
FEB	3.59	91	69	58	54	46	42	36	28	20	11	0	0
MAR	4.92	93	86	78	71	63	52	45	34	23	8	1	0
APR	(3.92)	87	74	64	58	51	41	33	23	11	3	0	0
MAY	3.60	81	66	56	50	45	37	30	19	4	1	0	0
JUN	4.65	93	88	82	75	67	56	44	18	1	0	0	0
JUL	4.20	89	80	72	63	54	46	35	13	0	0	0	0
AUG	5.10	95	90	84	77	70	61	51	35	10	0	0	0
SEP	(4.68)	89	83	76	70	62	55	46	33	18	2	0	0
OCT	(5.07)	97	95	89	84	78	70	61	42	27	4	0	0
NOV	3.39	87	72	60	55	47	39	33	25	16	2	0	0
DEC	2.95	88	78	68	63	52	44	34	23	13	1	0	0

SOLAR RADIATION DATA for: BILLINGS,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	4.03	95	83	76	71	64	56	46	35	23	4	0	0
FEB	(3.85)	95	86	75	63	54	45	35	25	16	5	0	0
MAR	4.31	92	81	71	64	56	49	41	32	22	10	1	0
APR	(4.12)	90	78	67	58	51	42	33	24	8	0	0	0
MAY	4.26	90	78	70	62	53	42	30	20	4	0	0	0
JUN	(4.70)	94	89	82	73	64	51	35	13	1	0	0	0
JUL	(5.11)	94	89	84	77	69	59	48	30	0	0	0	0
AUG	4.67	92	85	78	68	61	51	41	31	7	0	0	0
SEP	(6.27)	98	96	93	88	83	75	65	52	32	1	0	0
OCT	4.33	90	83	77	71	62	53	44	32	15	0	0	0
NOV	3.84	87	75	70	63	58	52	43	34	16	1	0	0
DEC	2.97	88	79	69	59	51	41	32	19	3	0	0	0

SOLAR RADIATION DATA for: BILLINGS,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.28)	90	76	67	59	54	44	38	26	15	1	0	0
FEB	3.31	84	74	61	52	45	37	30	25	16	5	0	0
MAR	4.02	90	74	63	56	50	43	36	26	15	5	0	0
APR	(5.17)	95	90	82	74	65	57	49	39	24	2	0	0
MAY	4.73	94	86	79	71	61	49	41	28	9	0	0	0
JUN	4.81	93	88	82	74	67	54	43	21	1	0	0	0
JUL	5.14	95	91	88	82	74	64	51	27	0	0	0	0
AUG	4.72	94	87	78	72	64	53	45	29	6	0	0	0
SEP	4.63	93	85	78	71	64	55	43	32	18	2	0	0
OCT	(4.54)	81	76	72	68	63	57	48	35	18	2	0	0
NOV	2.84	82	66	55	47	38	33	23	16	9	0	0	0
DEC	(1.89)	77	59	51	41	31	24	14	4	1	0	0	0

SOLAR RADIATION DATA for: BOZEMAN,MONTANA 1977

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.04)	84	67	60	52	42	36	30	23	17	7	0	0
FEB	3.75	91	81	69	59	52	42	35	27	13	2	0	0
MAR	(4.30)	94	85	73	60	54	43	38	33	25	16	5	0
APR	5.49	96	91	84	75	69	60	52	41	24	3	1	0
MAY	(3.85)	89	76	65	56	43	35	26	18	4	0	0	0
JUN	4.63	92	85	77	69	61	49	34	14	1	0	0	0
JUL	4.80	94	87	78	69	60	48	37	23	3	0	0	0
AUG	(4.78)	94	85	78	71	66	57	46	28	3	1	0	0
SEP	(4.73)	91	81	72	67	60	54	44	37	22	1	0	0
OCT	(4.41)	89	80	72	66	60	51	43	36	22	5	1	0
NOV	(1.99)	73	58	48	38	30	20	16	12	7	2	1	0
DEC	(1.93)	67	53	39	33	29	23	19	16	12	4	1	0

SOLAR RADIATION DATA for: BOZEMAN,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	2.53	84	65	51	43	36	32	26	21	14	7	1	0
FEB	(3.81)	95	82	69	59	53	46	40	34	24	17	4	1
MAR	(4.98)	96	91	83	71	65	55	47	38	27	12	2	0
APR	4.02	93	82	65	55	47	36	28	21	12	3	0	0
MAY	(3.75)	89	73	61	51	42	33	24	15	4	0	0	0
JUN	(4.45)	91	83	75	68	60	48	32	12	1	0	0	0
JUL	4.65	94	86	78	69	63	52	39	24	2	0	0	0
AUG	5.00	94	87	77	71	65	56	46	34	12	2	0	0
SEP	4.51	87	78	72	67	62	54	46	38	23	5	1	0
OCT	5.24	95	91	86	80	72	64	55	45	33	5	0	0
NOV	(2.92)	79	66	53	47	42	32	25	19	12	3	0	0
DEC	(2.35)	72	57	50	45	43	37	31	22	18	0	0	0

SOLAR RADIATION DATA for: BOZEMAN,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM)											
		>.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.95)	82	55	48	43	41	36	32	25	19	5	0	0
FEB	3.57	95	79	65	54	48	42	36	27	19	9	2	0
MAR	(4.40)	94	81	66	59	50	43	35	28	23	12	2	0
APR	4.11	94	83	72	59	52	42	32	19	10	1	0	0
MAY	(4.20)	91	80	69	59	50	39	29	19	4	0	0	0
JUN	4.78	94	87	77	69	59	48	37	21	0	0	0	0
JUL	5.32	94	90	86	79	70	61	49	27	1	0	0	0
AUG	(4.77)	93	86	78	72	62	52	40	25	8	1	0	0
SEP	(6.04)	97	94	90	84	78	71	61	48	31	4	0	0
OCT	3.96	88	77	69	62	53	44	37	29	18	1	0	0
NOV	3.95	93	82	74	67	56	50	42	34	20	1	0	0
DEC	2.60	79	66	60	52	42	33	28	19	6	1	0	0

SOLAR RADIATION DATA for: BOZEMAN,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM)											
		>.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.03)	83	67	56	50	45	39	32	24	14	3	0	0
FEB	(2.61)	91	66	45	35	30	27	19	13	8	5	1	0
MAR	(4.25)	96	85	73	60	48	43	30	22	17	9	2	0
APR	5.12	95	89	83	75	64	53	45	33	20	4	0	0
MAY	(4.15)	91	80	70	60	52	43	30	19	5	1	0	0
JUN	4.42	92	80	71	63	54	43	30	16	1	0	0	0
JUL	5.02	95	89	82	76	68	58	45	22	0	0	0	0
AUG	(4.91)	94	84	79	71	64	55	45	35	14	1	0	0
SEP	(4.24)	90	80	71	62	54	46	40	30	17	4	0	0
OCT	4.59	84	75	70	66	62	54	47	37	24	2	0	0
NOV	2.58	77	60	51	44	37	30	22	15	9	2	0	0
DEC	(2.07)	79	67	56	45	35	26	18	8	3	0	0	0

SOLAR RADIATION DATA for: BROWNING,MONTANA 1977

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB													
MAR													
APR	(5.77)	97	91	84	78	70	63	54	41	25	8	0	0
MAY	(4.40)	93	82	71	60	47	38	28	19	8	2	1	0
JUN	(4.51)	92	83	71	63	53	44	31	19	2	0	0	0
JUL	4.75	90	83	74	66	56	48	39	24	8	0	0	0
AUG	(3.91)	85	66	53	50	43	39	33	24	6	0	0	0
SEP	(4.11)	79	68	62	57	53	47	38	29	19	1	0	0
OCT	(4.15)	93	84	74	67	61	52	43	30	14	0	0	0
NOV	(3.04)	90	76	64	53	46	40	32	22	11	0	0	0
DEC	(1.99)	69	46	40	38	34	28	19	13	3	0	0	0

SOLAR RADIATION DATA for: BROWNING,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.04)	89	70	56	48	41	35	29	23	16	5	0	0
FEB	(4.05)	89	79	63	54	47	42	38	32	25	16	1	0
MAR	(4.14)	90	81	72	63	52	45	37	30	21	12	5	1
APR	3.64	87	66	55	48	40	34	28	19	11	4	0	0
MAY	(4.03)	87	71	61	54	44	38	32	23	10	1	0	0
JUN	5.24	94	87	83	77	69	59	45	26	1	0	0	0
JUL	4.65	91	81	73	65	57	51	42	29	5	0	0	0
AUG	(4.77)	93	83	75	68	59	52	42	32	14	3	0	0
SEP	4.90	90	82	76	70	65	58	47	37	27	7	1	0
OCT	4.60	92	84	81	73	65	55	43	33	21	4	0	0
NOV	(4.81)	98	95	90	90	80	71	64	43	12	0	0	0
DEC	(3.55)	98	95	95	81	60	45	10	0	0	0	0	0

SOLAR RADIATION DATA for: BROWNING,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB													
MAR	(4.75)	97	88	81	71	64	54	41	29	19	9	1	0
APR	(5.06)	95	86	78	69	60	52	44	36	24	11	2	0
MAY	4.41	90	76	65	55	47	39	32	23	7	1	0	0
JUN	(5.13)	94	86	79	70	61	50	40	26	6	0	0	0
JUL	(4.75)	89	81	74	68	59	51	42	30	3	0	0	0
AUG													
SEP	(5.75)	98	95	90	84	77	69	58	46	28	0	0	0
OCT	3.96	87	78	72	64	55	47	37	28	17	1	0	0
NOV	(3.06)	65	52	48	45	41	36	32	27	18	3	0	0
DEC													

SOLAR RADIATION DATA for: BROWNING,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB													
MAR	(4.39)	95	87	76	65	56	45	38	31	21	13	1	0
APR	(5.25)	94	87	80	70	64	52	42	36	21	4	0	0
MAY	(4.46)	86	78	67	60	51	43	36	25	6	0	0	0
JUN	(3.69)	87	73	60	49	34	26	22	13	0	0	0	0
JUL													
AUG													
SEP	(4.75)	92	83	77	70	65	59	50	39	28	0	0	0
OCT	(4.53)	89	83	76	71	64	56	48	37	22	1	0	0
NOV	(3.66)	89	80	73	66	60	53	43	32	14	0	0	0
DEC	(2.25)	80	57	44	35	26	18	13	9	2	0	0	0

SOLAR RADIATION DATA for: BUTTE,MONTANA 1977

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(4.57)	98	95	88	83	69	53	40	24	15	1	0	0
FEB	3.87	94	82	74	64	55	48	40	30	16	3	0	0
MAR	(3.85)	91	75	65	56	47	38	32	26	17	10	1	0
APR	5.41	97	91	84	74	66	59	50	41	25	2	0	0
MAY	(3.41)	89	70	57	43	31	24	18	13	4	0	0	0
JUN	(4.30)	91	84	76	64	55	43	31	11	1	0	0	0
JUL													
AUG													
SEP	(3.77)	90	75	66	53	48	39	33	24	14	4	0	0
OCT	4.47	95	87	80	71	63	53	44	32	20	3	1	0
NOV	(3.76)	96	88	80	70	62	50	39	28	16	4	0	0
DEC	2.08	70	46	40	37	34	29	24	17	11	1	0	0

SOLAR RADIATION DATA for: BUTTE,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.43)	87	59	45	38	34	27	22	17	11	2	0	0
FEB	3.67	93	76	67	60	53	43	37	28	19	8	1	0
MAR	(4.92)	96	88	81	71	64	56	49	40	28	9	1	0
APR	4.15	94	82	70	60	50	40	30	22	12	6	1	0
MAY	(3.36)	90	70	52	41	34	27	21	13	5	0	0	0
JUN													
JUL													
AUG													
SEP													
OCT	(4.21)	90	73	65	60	51	50	45	36	30	3	0	0
NOV	2.84	83	64	56	51	44	38	29	22	13	2	0	0
DEC	2.69	84	64	56	51	45	37	31	24	16	2	0	0

SOLAR RADIATION DATA for: BUTTE,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	3.63	89	74	66	58	51	46	40	34	24	6	0	0
FEB	3.37	93	77	67	57	48	40	30	23	17	10	2	0
MAR	4.56	93	78	65	58	51	44	39	32	26	15	0	0
APR	(3.96)	94	85	71	57	43	31	22	16	9	1	0	0
MAY	(4.22)	92	80	69	57	49	41	30	19	7	0	0	0
JUN	4.22	91	84	74	63	54	41	26	12	2	0	0	0
JUL	(4.57)	93	87	81	75	65	51	36	19	0	0	0	0
AUG													
SEP	(6.01)	98	95	90	85	78	70	62	51	33	3	0	0
OCT	3.87	89	78	71	63	57	51	39	30	18	3	0	0
NOV	3.91	89	79	75	67	60	53	46	36	21	2	0	0
DEC	2.69	88	74	67	58	49	39	32	19	9	1	0	0

SOLAR RADIATION DATA for: BUTTE,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	3.25	91	81	71	64	54	47	35	26	15	5	0	0
FEB	3.22	92	76	64	56	45	34	25	19	13	4	0	0
MAR	3.49	95	82	62	50	39	31	22	15	9	3	0	0
APR	4.62	95	85	74	65	57	47	38	29	17	3	0	0
MAY	3.80	87	75	62	54	47	36	26	17	7	1	0	0
JUN	3.74	92	81	69	56	45	37	24	11	1	0	0	0
JUL	(4.92)	94	90	83	76	67	55	41	21	1	0	0	0
AUG	(5.03)	94	90	84	77	70	60	48	36	16	0	0	0
SEP	4.37	90	81	74	67	60	49	38	31	19	3	0	0
OCT	(4.67)	91	83	75	70	64	57	49	40	28	6	0	0
NOV	3.19	90	81	71	64	52	45	38	27	13	3	0	0
DEC	2.33	74	64	54	47	38	27	19	13	6	0	0	0

THIS STATION NOT INSTRUMENTED IN 1977

SOLAR RADIATION DATA for: CHOTEAU,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB													
MAR	(3.97)	86	71	63	55	50	46	40	32	23	13	3	0
APR	(4.24)	92	74	62	53	47	41	35	30	23	12	2	0
MAY	(4.00)	89	73	63	53	46	40	33	27	15	2	0	0
JUN	4.90	95	88	79	71	63	53	41	24	5	1	0	0
JUL	4.54	92	80	73	66	58	51	42	25	5	0	0	0
AUG	(4.91)	94	83	76	68	62	53	43	33	12	2	0	0
SEP	(4.29)	80	72	67	62	55	50	41	32	18	1	0	0
OCT	4.58	93	84	78	71	63	54	42	31	17	1	0	0
NOV	(2.48)	74	54	50	44	37	34	28	22	10	0	0	0
DEC	2.63	87	68	61	54	47	37	29	22	4	0	0	0

SOLAR RADIATION DATA for: CHOTEAU,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.24)	89	70	60	54	48	42	33	26	16	1	0	0
FEB	3.50	94	79	67	57	49	42	35	27	14	5	0	0
MAR	(4.65)	96	86	79	71	63	53	45	35	25	13	0	0
APR	4.43	93	84	73	62	52	44	35	26	15	5	0	0
MAY	4.28	92	80	69	58	46	38	28	17	4	0	0	0
JUN	4.62	94	86	75	63	51	40	28	14	1	0	0	0
JUL	(5.17)	95	90	83	75	65	55	41	26	1	0	0	0
AUG	(4.77)	92	85	80	73	65	55	44	31	12	0	0	0
SEP	5.76	98	95	89	83	76	68	59	47	26	1	0	0
OCT	(4.45)	92	85	79	72	64	56	45	35	24	5	0	0
NOV	3.94	90	82	77	72	62	54	45	35	22	0	0	0
DEC	(2.96)	87	78	70	63	55	46	34	23	6	0	0	0

SOLAR RADIATION DATA for: CHOTEAU,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	3.15	86	76	69	61	53	45	35	23	10	0	0	0
FEB	(2.97)	86	71	57	49	41	32	25	19	13	3	1	0
MAR	(4.26)	94	81	70	62	53	46	37	31	20	7	1	0
APR	5.23	95	88	78	71	64	54	44	33	19	5	0	0
MAY	4.40	90	81	72	64	55	45	34	20	5	1	0	0
JUN	4.55	93	83	76	68	56	44	31	18	1	0	0	0
JUL	(5.16)	95	89	83	76	68	55	40	21	1	0	0	0
AUG	(4.70)	91	84	80	72	65	54	43	31	18	1	0	0
SEP	4.29	90	79	74	67	61	52	44	34	19	2	0	0
OCT	4.36	90	81	75	69	63	56	45	35	22	2	0	0
NOV	3.09	84	74	67	63	56	48	36	23	7	1	0	0
DEC	1.32	49	39	33	27	21	17	10	6	1	0	0	0

SOLAR RADIATION DATA for: COLSTRIP,MONTANA 1977

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB	(4.31)	91	81	74	66	60	53	46	40	27	11	0	0
MAR	4.68	92	81	75	67	61	53	42	32	24	11	1	0
APR	(5.52)	96	90	84	77	69	61	51	38	22	1	0	0
MAY	(4.70)	91	80	73	66	58	51	38	24	6	1	0	0
JUN	(5.17)	94	90	86	79	68	51	36	9	0	0	0	0
JUL													
AUG													
SEP													
OCT													
NOV													
DEC													

SOLAR RADIATION DATA for: COLSTRIP,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB													
MAR	(4.94)	95	88	78	68	62	55	48	39	26	8	0	0
APR	4.25	86	73	66	57	50	44	36	26	17	3	0	0
MAY	(4.05)	82	71	62	55	50	44	34	20	2	0	0	0
JUN	4.70	93	86	78	71	64	55	41	18	3	0	0	0
JUL	(4.56)	92	83	73	66	57	50	38	20	1	0	0	0
AUG	5.16	93	88	82	75	68	60	50	34	11	0	0	0
SEP	(5.86)	97	94	91	86	79	71	61	45	28	3	0	0
OCT	4.96	92	87	82	76	70	61	52	39	28	5	0	0
NOV	(3.54)	88	75	61	53	44	40	32	26	17	4	0	0
DEC	(2.53)	89	69	56	45	36	31	21	18	10	2	0	0

SOLAR RADIATION DATA for: COLSTRIP,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB	(3.84)	92	82	67	58	49	42	36	27	18	10	1	0
MAR	(4.30)	91	81	70	62	53	46	39	30	17	6	1	0
APR	(3.66)	87	75	62	52	44	33	23	14	7	0	0	0
MAY	(3.18)	87	65	56	48	35	23	15	2	0	0	0	0
JUN	(4.19)	93	84	77	65	56	43	24	6	0	0	0	0
JUL	(4.85)	96	87	81	75	66	58	35	0	0	0	0	0
AUG	(4.22)	95	84	74	59	53	41	26	15	4	0	0	0
SEP	(5.24)	98	93	84	70	63	52	43	25	7	0	0	0
OCT	(4.82)	96	91	86	80	75	70	58	29	17	6	0	0
NOV	(2.66)	84	70	61	49	41	23	12	4	0	0	0	0
DEC	(2.93)	91	79	66	58	48	39	29	14	3	0	0	0

SOLAR RADIATION DATA for: COLSTRIP,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	2.85	84	73	67	56	46	38	25	11	1	0	0	0
FEB	(2.79)	78	61	53	45	38	31	25	14	7	3	0	0
MAR	4.15	90	78	68	59	50	41	32	23	15	7	1	0
APR	(4.83)	93	83	74	65	58	52	43	34	21	1	0	0
MAY	4.54	93	84	74	66	56	44	32	18	2	0	0	0
JUN	4.96	93	86	81	76	66	54	38	17	1	0	0	0
JUL	(5.28)	94	89	84	77	71	60	44	23	1	0	0	0
AUG	(6.36)	98	94	91	82	82	74	68	50	36	0	0	0
SEP	(4.92)	92	84	79	72	64	57	47	36	21	3	0	0
OCT	4.65	87	83	77	71	65	59	49	40	26	3	0	0
NOV	3.05	82	73	63	55	45	37	28	20	9	0	0	0
DEC	(1.98)	79	58	46	38	30	21	13	8	3	0	0	0

SOLAR RADIATION DATA for: DILLON,MONTANA 1977

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(4.48)	97	90	84	74	70	64	55	40	25	9	0	0
FEB	(4.25)	95	86	78	71	62	51	43	32	21	10	1	0
MAR	(3.94)	91	79	69	59	50	42	33	24	15	6	1	0
APR	(5.41)	97	91	85	76	69	60	52	43	22	5	1	0
MAY	(4.07)	93	82	71	56	46	35	25	14	3	1	0	0
JUN	4.57	92	81	72	63	58	50	38	21	2	0	0	0
JUL	(5.01)	91	84	79	72	64	56	46	32	4	0	0	0
AUG	(4.17)	86	72	67	62	57	47	39	28	7	2	0	0
SEP	4.91	94	86	80	73	64	57	49	38	24	2	0	0
OCT	(4.87)	95	88	81	75	67	57	45	33	21	7	0	0
NOV	3.06	91	74	62	54	46	38	30	22	13	3	0	0
DEC	(2.04)	73	57	50	42	34	27	17	8	2	0	0	0

SOLAR RADIATION DATA for: DILLON,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.39)	83	67	53	45	36	32	22	17	8	1	0	0
FEB	4.37	91	79	73	68	62	56	48	40	29	19	1	0
MAR	(5.35)	96	92	84	79	72	64	56	45	34	17	1	0
APR	(4.64)	94	84	73	62	52	45	38	31	23	8	0	0
MAY	3.87	91	81	68	51	43	35	24	14	5	1	0	0
JUN	5.13	94	90	82	75	67	55	42	22	3	0	0	0
JUL	(4.71)	94	88	80	69	60	49	37	21	2	0	0	0
AUG	(4.72)	95	88	81	68	61	51	38	23	9	0	0	0
SEP	(5.38)	96	92	83	77	71	65	56	41	30	11	1	0
OCT	5.92	98	96	91	86	80	72	63	51	35	14	0	0
NOV	(3.78)	88	76	68	61	57	51	43	36	26	13	0	0
DEC	3.34	91	77	69	65	60	54	44	36	24	6	0	0

SOLAR RADIATION DATA for: DILLON,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.83)	92	77	70	62	58	49	43	34	21	9	0	0
FEB	3.69	95	85	71	60	50	42	32	24	13	6	0	0
MAR	(4.90)	96	87	75	65	56	50	41	34	23	8	0	0
APR	4.94	94	86	77	69	58	51	40	30	19	4	1	0
MAY	(4.72)	94	85	72	64	55	44	33	21	7	0	0	0
JUN	(4.62)	93	86	75	65	54	40	27	16	2	0	0	0
JUL	(5.31)	94	87	81	74	67	58	47	32	3	0	0	0
AUG	5.19	93	85	79	74	68	60	50	37	17	4	0	0
SEP	6.31	97	95	92	87	81	74	66	55	35	3	0	0
OCT	(4.83)	94	88	82	75	66	59	50	40	29	8	1	0
NOV	(4.52)	94	85	77	68	64	56	48	36	25	5	0	0
DEC	3.30	93	83	73	66	59	50	39	24	5	0	0	0

SOLAR RADIATION DATA for: DILLON,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	3.36	91	79	67	59	52	46	39	28	18	6	0	0
FEB	3.89	93	83	76	69	59	51	39	29	18	7	1	0
MAR	4.17	96	87	74	59	49	41	32	23	14	4	0	0
APR	5.08	93	87	80	73	64	56	48	38	22	3	0	0
MAY	4.31	92	80	69	60	49	41	32	22	5	0	0	0
JUN	(4.57)	93	84	74	63	52	43	31	19	1	0	0	0
JUL	5.38	95	89	84	77	69	60	47	31	4	0	0	0
AUG	(5.57)	97	92	86	80	72	62	51	35	12	0	0	0
SEP	4.85	93	87	80	75	64	54	47	36	23	3	1	0
OCT	(4.58)	88	80	75	72	64	56	46	35	17	1	0	0
NOV	3.19	90	77	68	56	48	41	32	23	14	3	0	0
DEC	(2.60)	88	76	67	58	50	35	27	17	2	0	0	0

THIS STATION NOT INSTRUMENTED IN 1977

SOLAR RADIATION DATA for: ENNIS,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB	(4.90)	95	87	78	68	63	57	54	49	39	27	6	0
MAR	5.19	97	91	84	76	68	59	48	40	27	13	2	0
APR	(4.53)	93	84	75	62	53	46	37	29	21	9	3	0
MAY	(4.03)	89	79	66	55	43	36	24	17	6	0	0	0
JUN	(4.62)	91	83	74	66	58	48	39	25	4	0	0	0
JUL	(3.86)	98	94	90	84	73	60	40	10	3	0	0	0
AUG													
SEP	(6.42)	99	96	94	85	76	68	63	51	33	0	0	0
OCT	5.34	96	91	84	79	75	66	58	48	33	5	0	0
NOV	(2.64)	87	58	46	41	37	32	26	21	14	3	1	0
DEC	(2.81)	88	71	63	54	48	39	33	25	13	1	0	0

SOLAR RADIATION DATA for: ENNIS,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM)											
		>.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	3.48	89	68	60	53	49	43	38	30	21	6	0	0
FEB	(3.42)	91	73	57	51	43	38	32	28	19	11	1	0
MAR	(4.88)	96	89	77	67	58	50	42	35	25	12	1	0
APR	(4.10)	94	83	68	55	47	33	27	17	9	2	0	0
MAY	4.07	90	77	66	56	45	37	26	16	4	0	0	0
JUN	(4.55)	93	84	75	65	57	46	35	17	1	0	0	0
JUL	4.87	94	88	80	73	63	53	40	22	1	0	0	0
AUG	(4.59)	91	83	76	69	62	53	41	30	10	0	0	0
SEP	(6.10)	98	95	90	86	80	73	63	50	33	2	0	0
OCT	4.43	93	85	77	71	65	57	46	35	24	7	0	0
NOV	(4.08)	91	81	75	71	64	57	50	38	27	7	1	0
DEC	2.84	85	71	62	54	51	44	34	26	12	0	0	0

SOLAR RADIATION DATA for: ENNIS,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM)											
		>.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.35)	87	74	65	59	53	46	40	32	22	7	0	0
FEB	3.27	89	75	59	51	44	35	28	21	13	8	0	0
MAR	(3.86)	93	83	68	59	50	41	32	23	12	6	2	0
APR	(5.31)	96	91	84	78	70	61	51	36	19	4	0	0
MAY	4.01	91	80	69	58	45	37	27	17	4	0	0	0
JUN	4.36	92	80	69	61	54	45	34	16	1	0	0	0
JUL	(4.23)	92	83	75	66	58	48	34	19	2	0	0	0
AUG	4.63	92	84	76	69	62	52	43	32	15	2	0	0
SEP	(4.10)	90	80	72	67	58	49	39	28	18	3	0	0
OCT													
NOV													
DEC													

THIS STATION NOT INSTRUMENTED IN 1977

SOLAR RADIATION DATA for: FORT BENTON,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB	(3.88)	94	82	77	66	57	51	45	31	20	6	0	0
MAR	(4.25)	95	84	73	62	55	49	41	30	18	8	0	0
APR	(3.62)	90	69	59	53	47	37	28	17	11	3	0	0
MAY	3.52	84	70	60	51	41	32	26	16	5	0	0	0
JUN	(4.82)	93	87	81	73	62	52	40	13	1	0	0	0
JUL	(5.51)	95	91	82	78	70	63	49	34	3	0	0	0
AUG	5.14	94	87	79	73	66	59	46	32	11	1	0	0
SEP	(4.05)	83	75	68	62	55	47	38	31	17	1	0	0
OCT	(4.25)	90	83	77	70	62	55	44	33	18	2	0	0
NOV	(2.82)	80	66	52	45	39	34	28	20	6	0	0	0
DEC	(1.77)	85	71	54	47	37	26	9	0	0	0	0	0

SOLAR RADIATION DATA for: FORT BENTON,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	2.70	89	73	64	56	50	41	30	0	0	0	0	0
FEB	(3.15)	91	73	65	59	51	45	34	22	10	0	0	0
MAR	4.21	93	83	70	60	51	45	38	30	19	3	0	0
APR	3.80	89	73	65	57	50	41	32	22	9	1	0	0
MAY	3.81	92	73	62	54	44	34	25	16	3	1	0	0
JUN	4.59	95	88	77	69	59	48	37	21	1	0	0	0
JUL	(4.66)	93	83	73	67	60	52	40	26	1	0	0	0
AUG	(5.05)	96	88	82	75	68	58	48	36	14	1	0	0
SEP	5.63	98	94	91	86	78	69	59	49	29	3	0	0
OCT	3.88	88	81	75	68	61	51	42	33	17	0	0	0
NOV	2.91	89	75	67	61	55	44	33	24	5	0	0	0
DEC	2.16	80	69	62	54	47	36	26	11	0	0	0	0

SOLAR RADIATION DATA for: FORT BENTON,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.43)	86	74	66	54	45	34	27	15	3	0	0	0
FEB	(2.86)	84	74	59	46	37	25	18	13	8	3	0	0
MAR	3.77	91	77	68	58	51	42	34	27	19	5	0	0
APR	4.90	95	84	79	70	66	56	46	35	18	3	0	0
MAY	4.48	93	83	76	67	56	46	37	20	0	0	0	0
JUN	4.68	93	84	78	70	61	49	33	17	3	0	0	0
JUL	5.44	95	90	85	78	68	57	44	28	1	0	0	0
AUG	4.83	94	86	78	67	57	49	39	26	10	0	0	0
SEP	4.36	92	81	73	65	58	49	40	31	18	2	0	0
OCT	4.04	81	74	69	66	60	51	40	30	15	0	0	0
NOV	(2.46)	76	63	56	49	42	33	26	20	3	0	0	0
DEC	1.44	63	44	36	29	22	14	10	3	0	0	0	0

SOLAR RADIATION DATA for: GLASGOW,MONTANA 1977

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.43)	93	77	69	62	56	46	35	22	11	0	0	0
FEB	3.94	90	81	73	65	59	49	39	28	14	1	0	0
MAR	4.48	90	82	73	65	54	47	38	29	18	2	0	0
APR	5.51	94	90	84	76	68	58	49	36	15	1	0	0
MAY	(4.62)	87	77	70	64	57	48	35	22	3	0	0	0
JUN	4.54	93	84	75	66	58	45	31	12	1	0	0	0
JUL	(4.87)	94	88	80	71	63	51	40	20	1	0	0	0
AUG	4.24	93	80	69	57	46	37	29	20	7	0	0	0
SEP	3.58	84	68	60	50	43	35	25	19	10	1	0	0
OCT	4.27	91	84	78	71	61	52	41	30	15	1	0	0
NOV	(3.19)	88	77	67	56	49	40	32	20	5	0	0	0
DEC	2.08	81	55	45	38	32	26	21	11	0	0	0	0

SOLAR RADIATION DATA for: GLASGOW,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.25)	94	80	63	55	48	41	32	25	13	1	0	0
FEB	3.75	94	79	62	51	43	37	32	27	21	13	5	0
MAR	4.45	95	85	71	60	53	44	38	30	20	6	0	0
APR	(3.77)	82	64	56	50	42	37	31	25	18	7	1	0
MAY	4.28	90	77	64	56	49	40	31	20	5	0	0	0
JUN	(4.95)	93	86	78	70	62	53	41	23	1	0	0	0
JUL	(5.09)	91	83	77	70	64	54	43	27	4	0	0	0
AUG	(5.08)	94	87	80	72	64	55	43	29	9	1	0	0
SEP	(5.07)	86	80	75	71	63	57	49	38	23	6	1	0
OCT	(4.86)	91	85	78	74	66	57	46	37	25	12	1	0
NOV	(3.01)	88	67	58	52	45	39	33	26	16	8	0	0
DEC	(2.89)	91	70	60	55	49	44	35	24	12	3	0	0

SOLAR RADIATION DATA for: GLASGOW,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	3.51	96	87	77	68	57	49	37	24	7	0	0	0
FEB	3.86	95	78	66	59	52	46	37	29	21	7	0	0
MAR	5.22	97	91	81	73	63	54	46	36	25	8	1	0
APR	(4.16)	88	75	66	55	46	38	30	20	8	1	0	0
MAY	4.14	88	77	68	59	49	38	29	18	2	0	0	0
JUN	(5.38)	95	89	83	76	68	58	45	27	4	0	0	0
JUL	(5.22)	95	89	82	72	65	53	39	22	4	1	0	0
AUG	(5.21)	95	88	81	72	65	56	42	29	9	0	0	0
SEP	(5.73)	96	92	85	80	75	67	57	43	22	1	0	0
OCT	4.41	92	86	79	69	63	55	40	29	16	0	0	0
NOV	2.97	84	70	63	53	46	39	31	19	3	0	0	0
DEC	2.49	82	69	63	54	45	36	23	8	0	0	0	0

SOLAR RADIATION DATA for: GLASGOW,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.95)	88	71	64	59	50	41	32	19	7	0	0	0
FEB	3.96	95	78	70	63	57	48	40	30	18	1	1	0
MAR	4.41	96	87	77	67	58	47	35	25	14	2	0	0
APR	5.40	95	88	78	70	64	57	46	35	17	0	0	0
MAY	(5.47)	94	88	81	73	66	56	44	29	7	0	0	0
JUN	5.19	94	86	80	72	62	51	39	21	1	0	0	0
JUL	(5.44)	95	91	85	78	69	59	44	27	2	0	0	0
AUG	4.63	94	86	74	66	58	48	36	25	7	0	0	0
SEP	4.40	94	85	77	68	58	47	35	26	13	0	0	0
OCT	4.33	90	82	75	69	61	53	41	29	15	0	0	0
NOV	(3.22)	90	75	66	60	52	41	31	20	4	0	0	0
DEC	(2.19)	80	60	54	47	40	31	20	9	1	0	0	0

SOLAR RADIATION DATA for: GLENDIVE,MONTANA 1977

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.28)	82	70	59	54	46	40	38	33	25	18	0	0
FEB	4.00	93	81	72	65	58	52	44	34	23	4	0	0
MAR	4.27	89	78	70	63	56	46	35	24	13	2	0	0
APR	5.31	96	90	82	72	64	57	49	38	18	1	0	0
MAY	(4.87)	93	85	78	71	62	53	41	29	2	0	0	0
JUN	4.73	95	87	80	70	59	48	31	13	0	0	0	0
JUL													
AUG	(4.21)	90	78	69	60	49	42	33	24	8	0	0	0
SEP	3.84	82	69	61	56	48	42	34	28	14	1	0	0
OCT	4.13	90	77	70	64	57	51	43	33	17	1	0	0
NOV	(3.03)	91	78	69	62	50	41	31	22	8	0	0	0
DEC	(2.19)	81	56	48	42	34	29	23	15	5	0	0	0

SOLAR RADIATION DATA for: GLENDIVE,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.04)	92	75	61	51	46	38	32	25	12	0	0	0
FEB	3.23	92	73	54	45	40	36	30	24	15	4	0	0
MAR	(4.09)	93	77	63	57	49	44	32	23	15	6	0	0
APR	3.55	81	66	57	48	41	34	27	19	12	1	0	0
MAY	3.56	83	67	56	48	39	32	21	12	1	0	0	0
JUN	(4.71)	93	85	76	68	59	50	38	16	1	0	0	0
JUL	(4.73)	93	86	78	70	60	49	35	15	1	0	0	0
AUG	(6.21)	97	94	92	87	82	74	66	43	9	0	0	0
SEP	(5.52)	95	91	86	81	75	66	54	39	21	2	0	0
OCT	4.05	91	83	77	71	63	55	44	27	13	0	0	0
NOV	(2.63)	81	57	49	46	37	32	24	16	8	0	0	0
DEC													

SOLAR RADIATION DATA for: GLENDIVE,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM)											
		>.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB	(3.65)	97	87	80	72	57	47	25	17	9	3	0	0
MAR	(4.02)	96	86	75	65	54	42	36	32	22	10	0	0
APR	(3.58)	83	70	61	52	41	32	22	12	4	0	0	0
MAY	(4.50)	93	83	70	62	54	47	39	29	10	1	0	0
JUN	(4.80)	94	87	78	68	58	48	38	22	2	0	0	0
JUL	(4.77)	94	88	80	73	62	51	37	21	1	0	0	0
AUG	(4.80)	94	86	77	70	60	52	39	26	9	0	0	0
SEP	(5.22)	96	91	86	81	73	66	54	41	21	0	0	0
OCT	(3.13)	94	87	67	51	43	34	13	13	0	0	0	0
NOV													
DEC													

SOLAR RADIATION DATA for: GLENDIVE,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM)											
		>.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.47)	93	84	78	68	55	42	32	23	8	0	0	0
FEB	(2.93)	77	62	56	48	42	36	30	24	15	3	0	0
MAR	(4.67)	94	86	78	69	60	50	40	32	22	2	0	0
APR	5.02	94	85	75	66	58	50	42	31	15	0	0	0
MAY	5.36	94	87	82	74	64	54	42	28	4	0	0	0
JUN	(4.90)	91	83	76	71	63	54	42	26	2	0	0	0
JUL	(4.85)	93	85	78	69	60	50	35	21	0	0	0	0
AUG	(4.24)	83	78	72	64	53	43	32	19	0	0	0	0
SEP													
OCT	(3.45)	83	74	69	61	52	41	30	21	3	0	0	0
NOV	3.12	87	78	73	65	57	46	36	23	2	0	0	0
DEC	(1.90)	74	56	49	42	33	26	18	11	0	0	0	0

SOLAR RADIATION DATA for: GREAT FALLS,MONTANA 1977

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(1.51)	74	49	31	29	18	10	0	0	0	0	0	0
FEB	4.01	92	86	76	64	56	47	41	30	17	2	0	0
MAR	4.18	93	80	73	67	57	48	37	26	16	4	0	0
APR	5.24	97	89	82	74	66	57	44	28	11	1	0	0
MAY	4.34	91	78	67	58	49	37	31	20	4	1	0	0
JUN	4.86	94	86	79	70	61	50	37	19	1	0	0	0
JUL	5.09	95	89	80	72	63	53	40	24	4	0	0	0
AUG	4.42	91	79	67	60	52	46	36	26	11	1	0	0
SEP	4.41	88	77	69	63	57	50	42	33	22	2	0	0
OCT	4.06	88	79	72	65	60	52	45	33	19	3	0	0
NOV	(3.24)	92	78	70	62	52	44	33	22	10	1	0	0
DEC	(3.02)	87	76	67	61	53	46	37	26	5	0	0	0

SOLAR RADIATION DATA for: GREAT FALLS,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.02)	90	67	58	53	49	44	36	27	15	3	0	0
FEB	(3.75)	93	83	72	63	54	48	41	34	27	13	3	1
MAR	4.23	92	77	67	59	54	47	41	34	24	12	1	0
APR	4.19	94	77	65	55	48	42	35	28	20	8	3	0
MAY	4.08	89	76	63	55	49	43	36	26	13	3	0	0
JUN	5.01	93	87	80	73	66	57	46	29	6	1	0	0
JUL	4.83	91	81	74	68	62	55	44	30	5	0	0	0
AUG	(5.20)	92	86	80	73	67	58	48	34	14	1	0	0
SEP	4.54	89	79	72	67	59	51	42	33	20	3	0	0
OCT	4.40	90	84	75	67	61	55	46	36	23	2	0	0
NOV	(3.01)	82	66	57	50	44	40	34	25	12	0	0	0
DEC	(2.78)	87	72	63	58	49	43	35	25	10	0	0	0

SOLAR RADIATION DATA for: GREAT FALLS,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	3.32	91	70	66	58	52	44	35	26	14	1	0	0
FEB	(3.46)	91	76	67	58	48	43	36	26	16	6	1	0
MAR	4.40	92	82	71	62	54	46	40	34	24	9	0	0
APR	3.93	92	77	65	56	46	36	27	18	10	2	0	0
MAY	4.19	91	78	66	56	45	36	27	17	3	0	0	0
JUN	4.74	93	84	76	66	54	41	28	17	3	0	0	0
JUL	5.15	93	85	78	73	64	54	42	27	3	0	0	0
AUG	5.43	95	88	84	78	70	62	51	38	14	1	0	0
SEP	5.87	97	93	89	83	77	70	60	50	33	4	0	0
OCT	4.12	88	80	72	63	56	49	41	33	23	3	0	0
NOV	3.69	87	77	73	68	62	55	44	35	14	0	0	0
DEC	(2.89)	92	82	73	61	49	39	29	18	1	0	0	0

SOLAR RADIATION DATA for: GREAT FALLS,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.94)	92	81	70	57	45	40	29	19	7	0	0	0
FEB	2.87	81	61	50	45	36	32	27	16	9	3	0	0
MAR	(4.14)	93	79	68	60	52	44	34	27	19	7	0	0
APR	5.15	95	87	76	71	63	56	45	35	18	2	0	0
MAY	4.69	90	81	72	65	57	47	38	25	6	0	0	0
JUN	5.04	94	86	79	72	64	52	36	19	4	0	0	0
JUL	5.34	95	90	83	76	67	55	42	22	1	0	0	0
AUG	4.74	94	84	74	66	57	48	38	25	10	0	0	0
SEP	4.38	92	81	72	65	59	50	39	27	13	2	0	0
OCT	4.17	81	75	68	63	57	48	40	27	15	0	0	0
NOV	2.89	81	70	62	53	47	37	28	19	4	0	0	0
DEC	(1.49)	55	40	33	26	18	13	10	5	0	0	0	0

SOLAR RADIATION DATA for: HAMILTON,MONTANA 1977

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB													
MAR	(3.54)	92	77	66	56	44	33	27	19	14	8	1	0
APR	(5.24)	96	85	79	73	64	55	46	35	24	8	1	0
MAY	(3.81)	92	76	60	48	37	29	23	15	8	1	0	0
JUN	(4.52)	93	82	72	63	53	44	32	14	0	0	0	0
JUL	(4.16)	93	82	73	62	49	41	29	12	1	0	0	0
AUG													
SEP	(3.17)	89	69	57	47	35	28	21	15	7	3	0	0
OCT	4.13	92	80	72	64	58	50	37	27	17	3	0	0
NOV	(2.45)	83	62	53	47	39	34	29	18	12	1	0	0
DEC	(1.53)	65	44	30	26	22	19	15	10	1	0	0	0

SOLAR RADIATION DATA for: HAMILTON,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(1.50)	68	32	23	18	14	12	10	7	3	1	0	0
FEB	(3.04)	89	68	59	52	46	39	32	26	15	5	2	0
MAR	(4.41)	96	86	76	68	57	48	38	30	15	3	0	0
APR	(4.16)	93	85	75	60	50	41	30	19	10	2	0	0
MAY	(3.10)	88	65	49	40	30	24	15	7	3	1	0	0
JUN													
JUL													
AUG	(4.33)	85	77	69	64	51	43	32	18	3	0	0	0
SEP	(3.55)	87	69	60	52	48	39	29	16	6	0	0	0
OCT	(5.14)	94	89	83	78	71	65	55	44	21	4	0	0
NOV	2.18	70	48	44	36	32	26	17	12	3	0	0	0
DEC	(2.37)	80	60	51	42	37	31	25	17	4	0	0	0

SOLAR RADIATION DATA for: HAMILTON,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.15)	85	72	63	55	49	43	37	27	10	0	0	0
FEB	2.47	83	67	49	38	31	23	16	12	8	3	0	0
MAR	4.55	92	80	72	65	58	50	42	34	25	12	0	0
APR	3.98	92	82	68	55	45	36	24	18	9	1	0	0
MAY	4.65	94	83	72	61	51	41	33	24	12	0	0	0
JUN	(4.72)	90	82	73	65	56	46	35	22	3	0	0	0
JUL	5.01	92	86	80	72	65	53	41	25	3	0	0	0
AUG	(6.42)	96	93	90	85	80	71	59	45	10	0	0	0
SEP	(5.77)	98	94	90	84	77	69	58	46	26	1	0	0
OCT	3.87	88	74	67	59	52	46	39	30	20	3	0	0
NOV	(3.30)	88	79	73	68	55	47	38	24	5	0	0	0
DEC	1.78	73	58	49	37	29	21	13	5	0	0	0	0

SOLAR RADIATION DATA for: HAMILTON,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.75)	89	69	58	48	44	38	28	21	11	1	0	0
FEB	2.91	90	72	61	54	45	36	29	20	12	7	0	0
MAR	(3.32)	95	77	62	52	39	29	19	14	7	3	0	0
APR	4.44	93	84	76	67	56	47	37	29	10	3	0	0
MAY	(4.22)	89	79	68	60	50	43	33	23	3	0	0	0
JUN	4.33	94	83	74	64	53	42	31	15	1	0	0	0
JUL	(4.98)	96	90	85	78	68	56	43	24	0	0	0	0
AUG	(5.07)	97	91	84	77	67	55	45	30	6	0	0	0
SEP	(4.07)	93	82	73	63	53	45	35	28	16	0	0	0
OCT	4.58	91	86	81	75	67	59	49	38	23	3	0	0
NOV	(2.79)	86	72	63	55	46	39	28	20	8	1	0	0
DEC	(2.09)	73	59	48	44	37	28	20	13	3	0	0	0

SOLAR RADIATION DATA for: HARLOWTON,MONTANA 1977

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM)											
		>.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.22)	95	90	84	71	54	49	49	23	13	0	0	0
FEB	(4.60)	95	87	79	68	59	53	45	38	27	12	0	0
MAR	4.60	95	85	77	71	61	53	46	33	22	9	0	0
APR	5.58	96	87	81	74	68	63	53	40	26	6	0	0
MAY	(4.28)	90	78	68	59	50	40	31	23	10	0	0	0
JUN	(5.30)	95	90	85	81	74	61	45	24	0	0	0	0
JUL	(4.75)	94	86	76	68	60	52	42	26	7	0	0	0
AUG	4.72	92	83	75	67	59	50	41	31	16	1	0	0
SEP	4.85	93	84	78	73	64	55	44	36	22	7	1	0
OCT	(4.46)	88	80	73	67	61	53	46	34	19	2	0	0
NOV	(2.57)	87	64	50	41	34	28	21	12	6	0	0	0
DEC	2.79	80	63	56	50	44	39	30	22	14	0	0	0

SOLAR RADIATION DATA for: HARLOWTON,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM)											
		>.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.17)	90	69	57	53	47	40	33	24	15	2	0	0
FEB	3.64	95	79	65	54	48	39	31	23	15	6	0	0
MAR	5.01	93	84	78	70	63	57	47	37	26	9	0	0
APR	3.98	88	74	63	52	45	38	33	22	15	6	1	0
MAY	(3.77)	88	71	58	49	40	32	25	18	9	1	0	0
JUN	(4.44)	88	81	74	68	60	51	40	21	1	0	0	0
JUL	4.50	89	80	72	64	56	47	38	21	1	0	0	0
AUG	(5.14)	96	90	82	75	67	58	47	31	10	1	0	0
SEP	(4.62)	87	77	73	65	59	52	45	36	23	4	0	0
OCT													
NOV													
DEC													

SOLAR RADIATION DATA for: HARLOWTON,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(4.98)	97	95	88	80	69	62	54	43	28	5	1	0
FEB	3.90	92	84	73	65	56	47	36	26	16	7	0	0
MAR	(4.87)	92	80	71	66	59	53	43	33	25	15	0	0
APR													
MAY	(4.21)	91	76	66	57	48	38	28	19	7	1	0	0
JUN	4.69	93	86	77	67	57	48	35	19	1	0	0	0
JUL	(5.56)	94	91	86	80	73	62	44	19	0	0	0	0
AUG	(4.57)	91	80	75	68	61	52	39	31	16	0	0	0
SEP	5.99	98	95	90	83	77	70	61	48	32	6	0	0
OCT	(4.43)	92	85	76	70	61	53	44	32	17	1	0	0
NOV	3.68	88	76	68	61	56	47	40	29	14	1	0	0
DEC	(3.12)	90	82	70	63	54	43	33	22	4	0	0	0

SOLAR RADIATION DATA for: HARLOWTON,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	3.27	87	73	64	58	51	46	36	27	12	0	0	0
FEB	(3.21)	87	73	60	49	40	32	23	16	12	4	0	0
MAR													
APR	(5.41)	96	90	85	80	67	61	52	39	17	0	0	0
MAY	4.53	92	83	74	65	57	46	34	22	7	1	0	0
JUN	(4.48)	92	82	73	66	58	48	37	18	2	0	0	0
JUL	5.21	95	90	85	78	69	58	46	27	2	0	0	0
AUG	(4.71)	94	85	77	69	58	49	41	30	11	2	0	0
SEP	(5.01)	96	91	85	78	72	59	53	34	22	0	0	0
OCT	4.43	88	77	71	66	57	49	39	32	20	0	0	0
NOV	3.45	87	73	65	58	51	44	35	25	10	0	0	0
DEC	(2.56)	89	72	59	51	38	31	21	14	1	0	0	0

SOLAR RADIATION DATA for: HAVRE,MONTANA 1977

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB	(4.17)	94	85	77	67	60	54	45	37	21	8	0	0
MAR	(4.60)	94	85	74	66	58	53	45	34	22	10	1	0
APR	(5.49)	96	91	84	78	70	62	50	35	16	2	0	0
MAY	(4.57)	89	81	75	68	59	50	36	24	7	1	0	0
JUN	(4.68)	92	82	75	68	60	49	36	20	1	0	0	0
JUL	4.66	91	83	76	68	60	49	37	21	2	0	0	0
AUG	(4.42)	90	77	67	62	52	45	37	26	7	0	0	0
SEP	4.05	81	71	65	58	52	47	39	31	22	4	1	0
OCT	4.38	92	87	79	71	62	51	41	33	19	1	0	0
NOV	(3.25)	85	69	63	58	51	44	38	30	15	0	0	0
DEC	(2.38)	81	66	57	51	44	34	24	14	3	0	0	0

SOLAR RADIATION DATA for: HAVRE,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.75)	91	67	54	44	37	31	24	18	11	2	0	0
FEB	3.73	95	81	68	60	50	41	35	25	15	3	0	0
MAR	4.33	95	86	76	65	55	45	32	22	14	3	0	0
APR	3.40	80	61	51	45	40	33	27	18	9	2	0	0
MAY	(3.84)	84	74	64	55	48	39	31	20	8	1	0	0
JUN	4.73	92	86	81	73	65	53	40	20	1	0	0	0
JUL	(4.42)	89	83	75	69	59	50	37	23	3	0	0	0
AUG	(3.41)	90	77	70	70	70	62	53	53	28	0	0	0
SEP	4.58	87	80	73	66	59	51	41	33	22	5	0	0
OCT	4.53	89	80	75	70	63	55	48	38	22	3	1	0
NOV	2.82	86	64	57	49	42	35	26	18	10	1	0	0
DEC	2.11	78	58	50	43	35	27	19	10	1	0	0	0

SOLAR RADIATION DATA for: HAVRE,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.51)	94	87	80	73	60	48	34	18	4	0	0	0
FEB	(3.16)	93	70	56	51	45	35	26	18	8	2	0	0
MAR	4.88	94	86	80	71	63	54	46	36	25	8	1	0
APR	(3.73)	88	74	65	55	46	37	28	16	5	0	0	0
MAY	(4.50)	93	84	75	64	54	44	34	24	10	0	0	0
JUN													
JUL													
AUG	(4.17)	89	74	65	59	51	43	36	27	1	0	0	0
SEP	5.39	97	93	88	81	74	65	54	40	18	1	0	0
OCT	4.07	91	82	74	66	61	51	39	29	14	0	0	0
NOV	3.47	83	69	64	57	53	47	39	26	7	0	0	0
DEC	(2.44)	84	73	63	54	43	32	24	13	1	0	0	0

SOLAR RADIATION DATA for: HAVRE,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	2.75	82	69	63	54	43	35	28	17	6	0	0	0
FEB	(3.17)	81	69	61	54	48	39	28	20	9	0	0	0
MAR	(4.24)	94	80	71	62	55	45	34	27	17	6	1	0
APR	5.29	94	84	80	74	68	61	51	37	19	2	0	0
MAY	(5.18)	94	89	83	75	66	55	42	28	7	0	0	0
JUN	4.38	91	84	78	70	60	45	31	10	2	0	0	0
JUL	3.80	93	86	77	63	47	13	4	2	0	0	0	0
AUG	(3.63)	91	82	70	58	41	23	8	5	3	0	0	0
SEP	(4.35)	90	84	75	68	58	48	41	28	17	3	0	0
OCT	(2.63)	75	60	47	43	36	29	20	11	4	0	0	0
NOV	2.67	77	65	57	48	38	33	26	19	7	0	0	0
DEC	(1.79)	73	49	41	36	28	24	17	10	1	0	0	0

SOLAR RADIATION DATA for: HELENA,MONTANA 1977

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.39)	87	64	54	43	36	26	21	13	7	2	0	0
FEB	(4.17)	91	83	76	67	58	50	42	32	18	7	0	0
MAR	(3.81)	93	78	64	53	46	37	29	22	13	5	0	0
APR	(5.11)	96	90	83	74	66	56	46	31	14	0	0	0
MAY	(4.07)	92	76	68	57	49	35	26	19	6	1	0	0
JUN	(4.65)	91	78	72	65	58	49	37	22	2	0	0	0
JUL	(5.07)	94	88	83	73	65	55	41	26	2	0	0	0
AUG	(4.74)	92	84	75	66	59	49	42	31	8	0	0	0
SEP	4.54	92	81	72	64	57	50	41	31	16	4	0	0
OCT	4.45	95	88	79	72	64	55	44	29	14	2	0	0
NOV	(3.11)	84	71	62	56	50	42	36	27	14	2	0	0
DEC	(2.29)	80	61	53	44	34	27	22	18	12	2	0	0

SOLAR RADIATION DATA for: HELENA,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.64)	87	63	47	40	36	31	25	18	11	5	1	0
FEB	(3.53)	94	82	66	56	46	37	30	24	14	8	1	0
MAR	(4.85)	96	88	77	69	59	51	43	33	18	9	0	0
APR	4.60	92	85	74	64	56	45	37	26	19	7	0	0
MAY	(3.56)	85	68	54	43	35	28	19	12	4	0	0	0
JUN	4.86	93	86	77	69	60	51	40	21	1	0	0	0
JUL	4.82	93	86	78	71	63	53	42	27	2	0	0	0
AUG	5.08	95	88	79	73	64	55	45	32	11	1	0	0
SEP	4.57	86	76	70	64	57	51	43	34	23	10	1	0
OCT	5.10	96	91	84	77	68	61	50	38	23	5	0	0
NOV	2.76	82	64	54	46	40	33	27	18	12	3	0	0
DEC	2.60	82	66	54	47	40	34	29	22	8	0	0	0

SOLAR RADIATION DATA for: HELENA,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.64)	92	77	67	62	56	48	39	30	18	2	0	0
FEB	(3.41)	93	77	65	55	45	37	28	20	13	6	2	0
MAR	4.67	95	85	74	64	54	47	39	31	20	7	0	0
APR	(4.34)	93	83	72	63	54	43	32	21	11	3	0	0
MAY	(4.43)	94	81	69	59	48	36	28	16	9	0	0	0
JUN	4.57	94	88	78	67	55	44	30	16	2	0	0	0
JUL	(4.84)	94	87	81	73	64	54	42	20	1	0	0	0
AUG	4.84	93	83	75	68	62	54	46	29	7	0	0	0
SEP	5.70	97	93	88	80	73	64	55	42	23	1	0	0
OCT	(4.05)	88	78	73	66	60	51	39	26	16	4	0	0
NOV	(3.62)	87	77	70	64	58	50	42	30	14	1	0	0
DEC	2.71	87	76	66	56	48	39	31	19	8	1	0	0

SOLAR RADIATION DATA for: HELENA,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.08)	92	76	67	58	50	38	31	22	13	2	0	0
FEB	2.91	83	69	55	45	36	31	25	17	9	4	0	0
MAR	(3.86)	93	82	67	55	46	37	31	21	14	6	0	0
APR	(5.11)	92	86	79	72	65	56	45	31	14	2	0	0
MAY	4.02	88	79	69	60	51	39	28	13	3	0	0	0
JUN	(3.37)	88	76	65	50	38	27	15	4	0	0	0	0
JUL	(3.02)	89	78	62	47	35	25	15	5	0	0	0	0
AUG	(3.88)	93	85	69	60	48	32	24	14	2	0	0	0
SEP	(5.06)	99	94	86	78	69	60	48	29	15	0	0	0
OCT	(4.47)	88	79	72	68	62	54	45	34	18	0	0	0
NOV	(3.09)	85	75	67	61	56	47	40	28	14	2	0	0
DEC	1.81	70	55	43	37	30	24	16	6	1	0	0	0

THIS STATION NOT INSTRUMENTED IN 1977

SOLAR RADIATION DATA for: JORDAN,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB													
MAR													
APR													
MAY	(4.12)	85	71	63	56	50	43	30	20	5	1	0	0
JUN	4.98	94	89	84	74	65	53	41	22	3	0	0	0
JUL	5.14	91	86	79	72	63	52	39	24	1	0	0	0
AUG	5.55	95	90	83	78	71	61	52	37	13	0	0	0
SEP	(4.91)	85	79	76	71	65	58	48	37	18	1	0	0
OCT	4.31	91	82	75	68	59	51	39	27	10	0	0	0
NOV	(2.38)	71	53	47	40	34	28	22	11	1	0	0	0
DEC	(2.09)	85	63	53	43	37	26	10	2	0	0	0	0

SOLAR RADIATION DATA for: JORDAN,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM)											
		>.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.09)	94	80	71	62	54	43	30	13	1	0	0	0
FEB	(3.36)	92	81	68	58	52	43	35	23	13	5	0	0
MAR	(4.21)	90	79	68	57	51	45	36	29	17	6	0	0
APR	4.17	87	74	62	53	45	38	30	22	14	5	0	0
MAY	(4.42)	93	83	70	61	50	41	31	19	11	1	0	0
JUN													
JUL													
AUG	(5.09)	95	89	83	74	67	56	43	26	2	0	0	0
SEP	6.03	97	94	89	85	78	70	60	47	26	1	0	0
OCT	(4.42)	91	84	78	73	67	60	50	37	14	0	0	0
NOV	3.34	86	76	68	62	56	48	38	25	3	0	0	0
DEC	(2.42)	79	65	57	50	42	34	24	18	0	0	0	0

SOLAR RADIATION DATA for: JORDAN,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM)											
		>.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.36)	86	74	65	60	55	46	36	24	14	1	0	0
FEB	3.69	86	72	63	56	49	43	39	30	21	5	0	0
MAR	4.64	94	87	78	70	61	50	42	30	19	6	0	0
APR	5.49	95	86	79	73	66	60	50	39	21	1	0	0
MAY	(5.06)	93	85	80	73	67	56	44	29	3	0	0	0
JUN	4.52	92	82	77	71	64	53	39	16	1	0	0	0
JUL	(4.84)	94	88	85	80	73	63	45	17	0	0	0	0
AUG	(5.81)	97	94	89	84	76	68	58	41	20	0	0	0
SEP	4.68	88	82	77	71	63	52	43	33	19	3	0	0
OCT	4.92	87	81	74	70	66	60	53	43	24	3	0	0
NOV	3.77	88	80	73	66	61	54	44	33	15	0	0	0
DEC	(2.27)	81	65	56	47	40	33	22	10	0	0	0	0

SOLAR RADIATION DATA for: KALISPELL,MONTANA 1977

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB	(2.80)	84	63	51	42	35	27	22	17	10	0	0	0
MAR	(2.99)	85	65	53	43	33	28	21	15	9	2	0	0
APR	5.01	95	87	77	70	61	50	40	32	20	0	0	0
MAY	3.89	91	76	65	55	42	34	23	15	5	0	0	0
JUN	(4.73)	93	81	72	63	54	46	33	17	1	0	0	0
JUL	(4.04)	87	75	62	51	41	33	23	11	3	0	0	0
AUG	4.75	90	80	73	68	60	54	45	33	13	1	0	0
SEP	(3.66)	83	72	63	54	46	38	31	22	12	1	0	0
OCT	(3.87)	91	78	71	63	58	49	38	28	12	0	0	0
NOV	(2.49)	74	55	52	48	43	35	28	19	9	1	0	0
DEC	(1.82)	63	46	34	31	25	18	15	11	6	0	0	0

SOLAR RADIATION DATA for: KALISPELL,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	1.55	77	30	25	21	15	12	9	7	6	3	0	0
FEB	2.78	89	65	52	43	37	32	26	20	14	4	1	0
MAR	4.34	94	77	66	58	50	44	38	33	24	13	6	0
APR	3.77	93	74	58	47	39	32	25	18	11	4	1	0
MAY	(3.69)	90	74	58	48	41	31	24	19	11	3	0	0
JUN	4.86	93	84	76	66	59	49	38	27	5	0	0	0
JUL	(4.73)	94	84	77	69	62	51	39	18	1	0	0	0
AUG	4.24	91	80	70	62	51	44	31	16	1	0	0	0
SEP	3.59	88	74	64	56	48	38	32	25	14	2	0	0
OCT	(4.69)	96	89	83	76	68	59	48	35	17	2	0	0
NOV	2.33	75	51	46	41	34	29	25	20	10	2	0	0
DEC	(1.99)	74	46	41	36	29	24	20	15	11	2	0	0

SOLAR RADIATION DATA for: KALISPELL,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.68)	81	60	51	47	43	38	33	26	11	2	1	0
FEB	1.92	82	48	30	23	19	13	10	8	4	2	1	0
MAR	4.49	94	83	72	64	56	50	44	33	22	4	0	0
APR	(4.11)	91	78	67	59	51	43	34	23	14	4	1	0
MAY	(4.41)	91	80	67	60	51	42	34	24	6	0	0	0
JUN	4.87	93	86	76	66	57	48	37	23	3	0	0	0
JUL	5.19	95	87	79	72	63	53	44	30	5	0	0	0
AUG	5.44	95	88	83	77	70	61	52	40	22	2	0	0
SEP	6.11	97	94	89	85	78	72	63	52	37	12	1	0
OCT	(3.44)	79	70	62	56	47	41	33	25	13	0	0	0
NOV	1.75	50	41	34	28	24	20	14	8	2	0	0	0
DEC	.73	34	22	17	12	10	8	6	4	2	0	0	0

SOLAR RADIATION DATA for: KALISPELL,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.88)	78	63	56	48	41	34	27	19	12	2	0	0
FEB	(2.40)	78	52	44	37	32	25	18	12	8	4	0	0
MAR	3.54	90	75	60	52	44	36	27	20	14	6	1	0
APR	(4.67)	87	79	72	64	57	49	40	27	12	0	0	0
MAY	4.08	88	76	62	52	45	38	30	18	5	0	0	0
JUN	(4.23)	90	80	67	58	47	34	22	10	0	0	0	0
JUL	4.79	91	83	75	68	60	50	40	22	2	0	0	0
AUG	4.81	93	84	76	69	61	51	40	29	11	0	0	0
SEP	4.24	91	79	73	66	58	51	38	27	14	2	0	0
OCT	4.16	91	82	77	69	62	52	41	33	18	0	0	0
NOV	1.67	71	59	48	39	32	26	19	8	3	0	0	0
DEC	1.10	43	32	24	22	16	12	9	5	0	0	0	0

SOLAR RADIATION DATA for: LEWISTOWN, MONTANA 1977

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB	(4.16)	93	73	66	60	53	49	43	36	24	8	0	0
MAR	4.47	96	87	76	63	56	48	39	31	19	7	0	0
APR	(5.44)	96	89	82	75	67	57	49	38	20	3	0	0
MAY	4.42	90	77	69	61	51	43	35	25	6	0	0	0
JUN	5.07	95	88	81	71	62	52	40	23	3	0	0	0
JUL	(4.73)	93	85	76	70	60	49	40	27	5	0	0	0
AUG	4.25	89	80	72	62	51	41	35	26	9	0	0	0
SEP	(4.70)	91	80	73	66	59	51	44	33	18	3	0	0
OCT	4.38	94	84	78	68	62	54	44	32	14	1	0	0
NOV	(2.97)	89	70	63	53	46	38	26	18	6	0	0	0
DEC	(2.85)	90	68	59	53	46	38	31	20	8	0	0	0

SOLAR RADIATION DATA for: LEWISTOWN, MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.71)	88	60	53	49	42	39	31	22	13	1	0	0
FEB	(3.66)	94	75	61	53	47	43	37	30	18	11	1	0
MAR	5.12	96	89	80	70	62	55	48	38	26	11	0	0
APR	(3.95)	89	76	64	54	45	36	29	24	15	6	0	0
MAY	(4.00)	87	76	64	56	45	36	26	19	6	1	0	0
JUN	4.89	91	85	78	71	63	53	42	24	4	1	0	0
JUL	(4.41)	93	80	72	63	52	44	35	19	2	0	0	0
AUG													
SEP	(4.49)	88	77	69	63	57	51	44	35	21	1	0	0
OCT	(4.91)	94	87	80	71	64	56	48	37	22	4	0	0
NOV	(2.89)	88	63	54	43	34	26	19	13	9	0	0	0
DEC	(2.99)	90	73	64	55	47	39	32	25	10	1	0	0

SOLAR RADIATION DATA for: LEWISTOWN,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.86)	94	78	70	66	62	53	43	31	9	2	0	0
FEB	(4.07)	94	85	77	69	60	50	40	29	15	5	0	0
MAR	(4.50)	92	81	72	62	56	47	40	33	25	15	0	0
APR	4.15	91	77	66	57	49	40	31	22	13	3	1	0
MAY	(4.15)	92	77	64	55	43	36	28	18	7	0	0	0
JUN	(4.96)	93	87	78	69	61	52	40	25	2	0	0	0
JUL	(5.32)	94	87	81	74	67	59	46	29	3	0	0	0
AUG	5.10	95	89	78	72	63	52	41	28	10	1	0	0
SEP	6.15	98	95	90	86	79	71	61	49	32	2	0	0
OCT	4.39	92	83	78	70	64	55	45	32	19	3	0	0
NOV	3.64	89	77	66	61	53	45	40	31	18	1	1	0
DEC	(3.06)	84	73	64	56	50	42	36	26	11	0	0	0

SOLAR RADIATION DATA for: LEWISTON,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	3.07	89	71	63	55	45	40	30	22	13	2	0	0
FEB	3.94	88	75	66	61	54	46	40	29	18	7	0	0
MAR	3.98	94	81	64	55	49	38	30	23	15	7	0	0
APR	(5.52)	97	92	87	79	68	59	49	39	22	5	1	0
MAY	4.79	95	88	80	70	59	46	35	22	4	0	0	0
JUN	4.64	92	81	74	67	60	50	38	22	1	0	0	0
JUL	5.17	95	90	82	75	65	54	41	26	1	0	0	0
AUG	4.93	95	88	79	71	64	54	41	29	10	1	0	0
SEP	4.26	90	78	69	59	52	44	35	27	17	4	1	0
OCT	4.48	85	74	68	63	59	54	46	38	25	4	0	0
NOV	3.29	82	70	64	57	51	43	37	28	14	0	0	0
DEC	(2.09)	75	58	48	42	34	29	20	13	2	0	0	0

SOLAR RADIATION DATA for: LIBBY,MONTANA 1977

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB	(3.27)	92	77	70	64	54	48	42	30	18	5	1	0
MAR	(3.42)	90	79	69	55	44	35	23	15	9	2	0	0
APR	(5.26)	96	90	79	73	65	56	46	35	19	2	0	0
MAY	(3.51)	90	71	56	45	36	26	18	11	5	0	0	0
JUN	(4.76)	94	85	77	68	57	46	32	23	3	0	0	0
JUL	(4.43)	91	80	71	59	49	40	32	23	8	0	0	0
AUG	(5.62)	95	88	82	78	71	63	52	40	17	0	0	0
SEP	(3.69)	87	73	64	54	45	36	30	24	15	2	0	0
OCT	(3.58)	92	81	72	64	58	49	40	32	14	0	0	0
NOV	(2.17)	81	63	51	43	37	31	20	13	3	0	0	0
DEC	(4.05)	97	96	92	92	87	81	72	54	22	0	0	0

SOLAR RADIATION DATA for: LIBBY,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB	(2.72)	92	70	55	46	37	32	28	21	9	3	1	0
MAR	3.76	92	76	64	55	49	43	36	28	16	7	1	0
APR	(3.41)	90	74	60	46	36	28	20	13	8	1	0	0
MAY	3.60	90	72	56	44	33	27	20	15	7	2	0	0
JUN	4.74	94	86	76	68	57	46	34	21	1	0	0	0
JUL	(4.50)	93	82	73	66	55	43	35	25	1	0	0	0
AUG	(3.75)	89	71	63	53	44	37	29	20	6	0	0	0
SEP	(3.21)	90	74	62	53	46	36	29	21	12	3	1	0
OCT	(4.13)	96	89	83	76	70	60	50	37	20	0	0	0
NOV	2.03	67	55	48	43	37	32	25	17	7	0	0	0
DEC	(1.61)	66	51	45	35	28	25	19	12	4	0	0	0

SOLAR RADIATION DATA for: LIBBY,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.91)	91	77	70	65	59	51	37	24	5	0	0	0
FEB	(1.66)	79	48	35	26	21	17	12	8	6	3	1	0
MAR	4.54	94	81	75	69	63	57	50	43	33	15	0	0
APR	(3.92)	92	81	66	55	45	35	26	20	9	1	0	0
MAY	4.59	93	83	73	65	56	48	37	25	13	2	0	0
JUN	4.87	94	87	77	69	60	49	35	21	5	0	0	0
JUL	4.92	94	86	79	71	62	51	38	22	4	0	0	0
AUG	(5.43)	96	89	85	80	71	63	53	39	15	2	0	0
SEP	5.40	96	91	85	80	73	66	57	45	26	2	1	0
OCT	(3.38)	81	69	61	55	46	41	32	23	9	0	0	0
NOV	(1.30)	55	44	37	30	25	19	12	4	1	0	0	0
DEC	(.80)	45	26	17	13	10	7	4	3	2	0	0	0

SOLAR RADIATION DATA for: LIBBY,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.26)	72	58	49	41	36	31	24	17	4	0	0	0
FEB	(1.56)	61	33	24	21	18	15	12	9	6	2	0	0
MAR	3.05	86	66	55	47	40	33	25	18	10	4	0	0
APR	(4.41)	93	82	71	63	55	46	35	25	12	1	0	0
MAY	3.69	84	69	59	50	41	32	25	15	4	0	0	0
JUN	4.00	91	78	63	55	44	35	25	13	1	0	0	0
JUL	4.82	91	83	74	67	58	50	37	22	2	0	0	0
AUG	4.42	92	83	72	64	53	43	32	21	9	1	0	0
SEP	(3.78)	85	76	67	61	55	49	37	29	12	2	0	0
OCT	(3.23)	86	72	66	56	49	42	32	23	7	0	0	0
NOV	(1.64)	62	50	41	35	29	24	15	9	2	0	0	0
DEC	(.94)	32	26	22	21	16	10	7	2	0	0	0	0

THIS STATION NOT INSTRUMENTED IN 1977

SOLAR RADIATION DATA for: LIVINGSTON,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB	(3.97)	95	76	66	62	54	49	39	30	22	16	6	0
MAR	4.64	93	83	75	68	59	54	46	38	30	20	4	2
APR	(4.22)	94	84	69	58	50	42	31	26	18	10	3	0
MAY	(3.60)	85	68	56	49	39	32	26	17	8	3	0	0
JUN	(5.23)	95	90	83	75	68	60	48	36	2	0	0	0
JUL	4.74	94	82	76	70	64	53	42	28	3	0	0	0
AUG	(5.11)	95	88	81	75	69	59	47	33	8	0	0	0
SEP	(5.11)	95	89	85	79	73	64	50	41	14	3	0	0
OCT	(4.71)	93	88	82	75	68	58	47	38	28	10	0	0
NOV	(4.00)	94	80	74	65	61	51	40	33	23	6	2	1
DEC	(2.21)	89	71	59	45	37	25	22	20	11	2	0	0

SOLAR RADIATION DATA for: LIVINGSTON,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.11)	91	82	54	48	41	36	31	26	19	7	0	0
FEB	(2.88)	87	66	51	44	40	35	29	23	15	9	2	0
MAR	(4.35)	91	81	72	64	56	48	41	32	21	13	4	1
APR	(4.01)	93	78	66	57	51	41	29	20	11	3	0	0
MAY	(5.32)	95	90	81	76	69	58	44	30	6	1	0	0
JUN	(5.56)	96	92	86	80	73	63	49	30	1	0	0	0
JUL	(5.20)	95	88	83	76	68	57	43	24	0	0	0	0
AUG													
SEP													
OCT													
NOV	(3.41)	93	78	73	68	60	47	38	29	18	0	0	0
DEC	2.43	75	62	58	52	47	40	28	19	3	0	0	0

SOLAR RADIATION DATA for: LIVINGSTON,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.85)	82	63	52	49	46	39	33	26	16	2	0	0
FEB	(2.98)	90	66	51	42	38	29	25	19	14	5	0	0
MAR	(4.02)	96	84	73	60	50	42	33	27	18	10	1	0
APR	(5.06)	95	88	82	74	66	54	45	34	21	3	0	0
MAY	4.24	92	80	72	63	54	45	32	20	5	0	0	0
JUN	(4.23)	90	82	73	63	52	41	28	15	1	0	0	0
JUL	4.96	95	89	82	76	69	60	45	27	2	0	0	0
AUG	(5.22)	96	91	86	82	73	63	52	36	10	3	0	0
SEP	(5.28)	97	93	87	83	71	61	55	45	28	8	1	0
OCT	(3.98)	86	71	67	62	55	49	43	34	21	2	0	0
NOV	2.92	86	71	61	55	46	38	28	18	10	3	0	0
DEC	(1.79)	71	50	41	32	25	18	13	8	1	0	0	0

SOLAR RADIATION DATA for: MILES CITY,MONTANA 1977

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.54)	92	74	67	63	53	47	37	26	16	5	1	0
FEB	4.26	91	82	75	69	63	54	46	36	25	4	0	0
MAR	4.49	91	83	74	64	57	48	39	29	19	4	0	0
APR	5.65	96	90	85	81	74	63	53	39	17	0	0	0
MAY	4.54	89	81	73	65	57	48	36	17	3	0	0	0
JUN	(5.10)	95	91	84	76	64	53	38	22	1	0	0	0
JUL	(4.96)	92	86	79	69	60	51	41	20	0	0	0	0
AUG	(4.54)	92	83	75	67	59	48	38	25	7	0	0	0
SEP	4.46	86	77	71	62	55	47	40	30	18	2	0	0
OCT	4.53	86	81	77	71	66	57	49	39	19	1	0	0
NOV	3.13	88	72	64	55	47	38	32	23	11	0	0	0
DEC	(2.29)	77	56	49	42	35	30	24	16	3	0	0	0

SOLAR RADIATION DATA for: MILES CITY,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	3.11	93	73	59	50	41	36	29	22	16	3	0	0
FEB	(3.87)	94	81	69	59	52	44	35	27	20	11	0	0
MAR	4.70	95	86	75	66	56	51	43	35	25	11	1	0
APR	4.05	83	73	61	53	47	41	35	27	19	3	0	0
MAY	3.71	82	66	56	46	41	35	27	17	2	0	0	0
JUN	4.64	94	86	76	66	56	45	33	11	0	0	0	0
JUL	(4.75)	93	87	78	68	58	50	37	17	1	0	0	0
AUG													
SEP	(4.80)	80	73	71	66	61	56	50	43	32	11	0	0
OCT	4.62	95	86	80	70	61	53	44	35	20	2	0	0
NOV	3.13	83	61	54	50	45	39	33	27	15	4	0	0
DEC	2.96	85	72	63	59	50	42	35	27	16	6	0	0

SOLAR RADIATION DATA for: MILES CITY,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Foulkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	4.09	97	91	83	75	66	57	47	37	21	4	0	0
FEB	4.33	96	87	78	71	63	53	45	35	24	11	0	0
MAR	5.06	95	84	77	71	65	58	49	41	33	21	5	0
APR	4.18	89	75	65	55	48	39	31	23	15	5	0	0
MAY	4.48	93	84	72	61	52	43	32	19	5	1	0	0
JUN	5.01	94	88	79	69	60	49	34	20	2	0	0	0
JUL	(4.93)	94	88	79	67	58	50	37	16	0	0	0	0
AUG	(4.97)	97	92	86	75	64	50	35	25	7	0	0	0
SEP	5.51	96	91	86	81	73	65	54	42	23	1	0	0
OCT	(4.37)	94	84	78	69	60	52	45	33	17	0	0	0
NOV	2.96	84	72	62	53	43	36	29	20	8	0	0	0
DEC	3.19	89	79	71	64	52	43	34	23	1	0	0	0

SOLAR RADIATION DATA for: MILES CITY,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Foulkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	3.19	83	73	67	60	54	47	35	24	12	0	0	0
FEB	(3.36)	83	66	60	54	48	42	37	26	18	5	0	0
MAR	4.17	93	83	72	62	53	40	31	21	14	4	0	0
APR	5.05	95	86	79	71	63	54	46	33	14	2	0	0
MAY	4.85	94	86	81	73	63	48	35	18	1	0	0	0
JUN	4.78	94	85	78	71	61	50	35	15	1	0	0	0
JUL	5.09	95	90	84	76	67	56	41	19	1	0	0	0
AUG	4.56	91	84	76	65	56	47	40	28	11	1	0	0
SEP	4.77	91	85	76	70	61	54	42	32	21	5	0	0
OCT	4.43	86	76	69	63	57	51	43	34	22	3	0	0
NOV	3.24	88	78	71	63	52	42	34	23	8	1	0	0
DEC	(2.00)	72	60	50	39	32	24	19	10	1	0	0	0

SOLAR RADIATION DATA for: MISSOULA,MONTANA 1977

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.82)	88	74	57	53	42	32	21	12	3	0	0	0
FEB	3.24	85	68	60	53	45	38	30	23	9	0	0	0
MAR	2.88	87	64	49	39	30	24	20	16	9	3	0	0
APR	5.14	96	87	80	73	65	57	44	33	20	5	0	0
MAY	3.59	89	72	57	49	39	29	21	13	6	1	0	0
JUN	(4.66)	94	84	77	66	54	44	30	18	2	0	0	0
JUL	(4.14)	91	79	68	60	51	40	27	13	2	0	0	0
AUG	4.66	92	81	72	66	60	53	42	32	11	2	0	0
SEP	(3.63)	90	73	64	52	46	40	34	29	16	3	0	0
OCT	(4.13)	93	81	73	66	58	49	39	30	17	3	0	0
NOV	(2.25)	83	68	58	50	40	33	24	13	4	2	0	0
DEC	(1.47)	68	43	30	29	20	17	13	9	4	0	0	0

SOLAR RADIATION DATA for: MISSOULA,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(1.46)	63	36	27	22	20	15	10	7	3	1	1	0
FEB	(2.39)	85	62	46	38	31	26	18	14	9	3	0	0
MAR	4.36	94	85	76	68	58	46	37	29	21	9	1	0
APR	4.03	95	83	71	59	48	39	27	20	12	4	0	0
MAY	(3.04)	87	64	49	36	29	21	14	10	5	1	0	0
JUN	4.50	91	83	75	67	58	49	33	14	2	0	0	0
JUL	4.70	93	84	76	68	58	50	39	25	4	0	0	0
AUG	4.59	92	83	74	66	58	46	35	23	4	0	0	0
SEP	(3.79)	81	70	63	56	48	41	29	23	15	3	1	0
OCT	(4.92)	97	91	85	76	69	62	50	39	23	9	1	0
NOV	(2.67)	76	64	56	51	45	39	30	19	10	1	1	0
DEC	1.93	74	55	47	40	33	27	19	9	2	0	0	0

SOLAR RADIATION DATA for: MISSOULA,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.70)	85	66	59	53	45	36	23	12	1	0	0	0
FEB	1.95	80	54	44	32	27	21	14	10	6	2	0	0
MAR	4.27	90	77	69	58	52	47	40	33	23	9	1	0
APR	3.74	91	77	66	48	40	32	25	18	10	1	0	0
MAY	(4.37)	92	80	69	59	51	41	32	20	6	1	0	0
JUN	4.82	90	83	76	68	59	48	39	26	2	0	0	0
JUL	5.05	94	89	83	75	68	55	44	27	2	0	0	0
AUG	4.96	92	85	80	73	67	58	48	34	12	1	0	0
SEP	5.94	98	94	90	83	76	69	57	45	30	3	0	0
OCT	(3.73)	87	73	62	57	49	44	37	29	19	3	0	0
NOV	2.42	74	62	55	48	41	33	25	9	1	0	0	0
DEC	(1.33)	56	43	35	30	25	19	12	5	1	0	0	0

SOLAR RADIATION DATA for: MISSOULA,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	2.79	81	66	58	53	47	38	29	19	6	0	0	0
FEB	2.10	78	57	45	38	29	23	13	8	2	1	0	0
MAR	2.92	92	72	57	43	35	26	17	10	5	2	0	0
APR	3.89	92	76	66	57	48	39	28	15	4	0	0	0
MAY	(3.79)	86	73	64	56	46	38	28	18	5	0	0	0
JUN	3.82	92	82	69	58	45	35	25	14	1	0	0	0
JUL	4.77	94	87	79	72	62	52	40	23	1	0	0	0
AUG	(5.02)	96	88	81	75	65	58	43	30	11	1	0	0
SEP	(3.89)	84	74	64	57	52	45	34	26	11	1	0	0
OCT	4.45	91	83	75	70	63	54	44	35	21	4	0	0
NOV	1.69	68	53	44	37	27	17	7	2	0	0	0	0
DEC	1.43	56	44	35	27	22	17	11	7	3	0	0	0

THIS STATION NOT INSTRUMENTED IN 1977

SOLAR RADIATION DATA for: PLENTYWOOD,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB	(4.52)	97	90	81	72	64	57	48	40	32	17	2	0
MAR	(4.86)	92	86	77	69	61	52	46	36	27	18	6	0
APR	(3.62)	79	65	55	49	44	38	33	24	13	4	0	0
MAY	(3.90)	85	74	64	55	44	34	25	14	4	1	0	0
JUN	(4.83)	92	82	75	68	58	50	40	24	5	0	0	0
JUL	(4.71)	93	85	77	71	61	50	38	19	3	0	0	0
AUG	(5.02)	95	89	82	77	69	60	47	32	14	1	0	0
SEP	(4.53)	90	83	79	73	66	58	48	36	18	1	0	0
OCT	(4.31)	95	86	81	74	65	57	47	34	22	9	0	0
NOV	(2.57)	79	61	51	46	40	33	26	18	3	0	0	0
DEC	2.45	87	69	55	46	41	32	25	13	2	0	0	0

SOLAR RADIATION DATA for: PLENTYWOOD,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.73)	95	87	82	73	63	57	51	31	8	0	0	0
FEB	3.52	94	80	62	53	44	40	36	29	19	7	0	0
MAR	4.20	91	76	65	59	53	46	38	32	23	15	3	0
APR	3.51	82	66	55	44	37	30	23	17	9	1	0	0
MAY	(3.66)	83	67	57	47	40	31	24	15	6	2	0	0
JUN	4.81	93	85	78	70	59	47	37	17	2	0	0	0
JUL	(5.03)	93	85	78	70	60	50	36	23	4	0	0	0
AUG	5.49	96	91	85	77	68	55	45	34	17	2	0	0
SEP	5.39	94	87	79	73	66	59	50	36	15	1	0	0
OCT	4.40	93	84	78	73	64	55	41	30	14	1	0	0
NOV	2.73	86	73	64	52	42	35	23	14	1	0	0	0
DEC	(2.96)	84	68	62	60	54	46	34	21	2	0	0	0

SOLAR RADIATION DATA for: PLENTYWOOD,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	3.31	89	77	72	66	55	47	37	27	7	0	0	0
FEB	(4.16)	94	83	74	68	60	52	44	34	24	9	0	0
MAR	(4.26)	94	81	70	62	53	43	37	26	15	5	1	0
APR	(5.29)	95	87	79	71	64	54	45	34	17	3	0	0
MAY	5.51	95	89	84	78	69	58	42	22	3	0	0	0
JUN	4.71	93	85	76	65	56	46	32	18	2	0	0	0
JUL	5.20	94	89	81	73	62	53	41	22	1	0	0	0
AUG	(4.84)	92	84	77	70	60	52	42	29	14	1	0	0
SEP	4.36	92	80	72	65	56	49	39	29	15	3	0	0
OCT	4.27	88	80	72	67	60	54	44	32	15	0	0	0
NOV	3.35	84	76	71	63	54	45	33	20	6	0	0	0
DEC	(2.20)	82	69	59	49	36	22	14	4	0	0	0	0

SOLAR RADIATION DATA for: POLSON,MONTANA 1977

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(1.96)	65	51	35	29	27	16	12	6	2	0	0	0
FEB	(2.75)	74	62	53	46	38	32	26	20	11	4	0	0
MAR	3.01	86	70	58	48	37	30	25	18	13	7	0	0
APR	5.19	94	88	78	72	61	52	43	33	17	2	0	0
MAY	4.00	92	78	66	56	46	37	27	17	6	1	0	0
JUN	4.67	93	84	75	66	56	44	33	15	0	0	0	0
JUL	4.53	92	82	73	64	54	45	34	23	3	0	0	0
AUG	4.95	92	86	77	69	62	56	47	35	12	0	0	0
SEP	3.97	87	77	68	63	52	43	33	24	16	2	0	0
OCT	4.07	88	80	73	65	58	48	41	31	20	5	0	0
NOV	(2.30)	78	63	57	52	42	36	27	21	12	3	0	0
DEC	(1.59)	65	41	31	24	22	20	18	14	10	2	0	0

SOLAR RADIATION DATA for: POLSON,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	1.33	80	34	22	14	10	7	6	5	3	2	0	0
FEB	2.77	90	72	54	44	34	27	20	14	11	5	0	0
MAR	4.65	93	83	72	65	59	52	45	37	27	15	6	1
APR	4.16	93	80	67	59	49	39	31	20	10	1	0	0
MAY	3.51	87	72	57	48	36	27	21	14	4	1	0	0
JUN	4.81	91	85	78	71	64	54	42	25	3	1	0	0
JUL	(4.98)	94	89	82	74	65	56	45	28	1	0	0	0
AUG	4.65	92	84	75	66	58	50	42	28	8	1	0	0
SEP	(3.75)	87	70	59	52	46	40	32	27	16	3	0	0
OCT	4.74	94	88	82	75	68	57	52	40	23	4	0	0
NOV	2.22	69	52	43	39	34	28	23	16	9	1	1	0
DEC	1.79	70	48	38	34	30	26	19	10	6	1	0	0

SOLAR RADIATION DATA for: POLSON,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.32)	92	62	49	40	37	30	25	17	7	1	0	0
FEB	(2.25)	88	56	39	31	23	20	15	12	9	6	0	0
MAR	4.56	93	83	73	64	54	50	42	36	27	10	1	0
APR	3.89	90	78	66	58	47	40	31	20	11	2	0	0
MAY	(4.53)	91	79	68	59	50	44	33	22	6	0	0	0
JUN													
JUL													
AUG	(4.61)	93	83	77	68	60	53	46	39	15	0	0	0
SEP	5.64	97	94	89	84	74	67	57	44	26	1	0	0
OCT	3.68	81	73	66	60	52	45	36	27	15	2	0	0
NOV	1.50	47	36	29	24	22	17	15	9	5	0	0	0
DEC	(1.11)	52	37	30	22	16	12	8	5	2	0	0	0

SOLAR RADIATION DATA for: POLSON,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	2.34	73	56	47	44	40	31	24	18	8	0	0	0
FEB	2.27	80	55	44	33	27	21	17	11	7	4	0	0
MAR	3.39	90	74	61	48	40	35	27	20	12	5	1	0
APR	4.52	90	79	69	62	54	46	38	28	14	1	0	0
MAY	4.08	87	77	64	57	49	41	32	23	5	0	0	0
JUN	4.39	91	80	70	59	53	42	31	17	0	0	0	0
JUL	4.99	94	86	79	70	63	51	40	26	1	0	0	0
AUG	(4.87)	94	85	78	72	64	56	44	32	12	0	0	0
SEP	4.20	89	78	71	64	57	45	37	28	16	1	0	0
OCT	(4.10)	91	78	72	64	58	49	40	33	19	0	0	0
NOV	(1.49)	61	47	38	33	26	18	11	6	1	0	0	0
DEC	(1.30)	48	40	34	27	22	20	16	9	3	0	0	0

THIS STATION NOT INSTRUMENTED IN 1977

SOLAR RADIATION DATA for: REDLODGE,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB	(3.60)	88	69	62	51	47	42	38	29	23	18	4	0
MAR	4.76	89	81	74	65	59	52	44	34	27	14	3	0
APR	(3.37)	83	71	61	49	39	34	27	20	12	3	0	0
MAY	3.59	85	67	57	48	41	35	24	15	7	1	0	0
JUN	(3.92)	91	79	64	51	43	35	28	17	2	0	0	0
JUL	4.29	88	78	70	61	54	45	35	23	6	0	0	0
AUG	(4.69)	92	81	73	66	61	53	44	31	11	0	0	0
SEP	(4.70)	91	82	75	67	56	48	39	31	21	6	2	0
OCT	(5.22)	97	93	89	83	75	66	57	44	25	3	0	0
NOV	3.42	90	72	64	57	50	42	33	24	16	3	0	0
DEC	3.18	93	82	75	65	58	50	40	29	11	0	0	0

SOLAR RADIATION DATA for: REDLODGE,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	3.79	95	83	69	63	57	53	44	35	24	6	0	0
FEB	4.05	95	85	76	68	58	50	42	31	20	6	0	0
MAR	(4.44)	92	81	73	65	58	51	43	31	19	8	1	0
APR	4.35	93	81	70	63	54	46	34	23	10	1	0	0
MAY	4.28	89	77	67	58	49	40	30	19	3	0	0	0
JUN	4.68	93	85	77	66	57	46	34	17	1	0	0	0
JUL	4.63	92	84	76	68	59	49	36	21	2	0	0	0
AUG	(4.28)	89	79	69	62	56	46	36	24	9	1	0	0
SEP	5.83	97	93	88	84	77	70	60	50	36	11	1	0
OCT	4.37	88	81	75	69	60	52	44	35	24	8	2	0
NOV	4.04	93	81	74	68	62	53	44	36	25	9	1	0
DEC	3.38	89	80	75	69	60	54	43	33	13	0	0	0

SOLAR RADIATION DATA for: REDLODGE,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	3.34	91	75	63	60	52	44	34	25	17	4	0	0
FEB	3.73	94	83	71	60	53	40	34	26	19	9	1	0
MAR	4.16	94	79	67	58	50	42	32	26	18	8	1	0
APR	(5.30)	97	91	82	75	67	55	47	36	20	3	1	0
MAY	4.00	91	79	69	56	44	35	23	14	2	0	0	0
JUN	4.57	93	83	75	67	58	48	34	17	0	0	0	0
JUL	4.42	94	87	79	70	61	48	33	19	2	0	0	0
AUG	4.24	91	80	69	61	53	43	36	24	8	0	0	0
SEP	4.48	93	79	70	63	57	51	43	33	22	5	1	0
OCT	4.84	93	83	74	67	61	54	47	39	28	10	0	0
NOV	3.32	85	69	61	54	47	41	34	27	19	9	1	0
DEC	2.56	82	67	59	53	46	36	25	19	9	0	0	0

THIS STATION NOT INSTRUMENTED IN 1977

SOLAR RADIATION DATA for: SIDNEY,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB	(4.56)	97	92	81	71	62	50	44	37	30	21	2	0
MAR	(4.74)	97	89	79	67	58	50	43	36	27	14	4	1
APR	(3.44)	82	61	53	46	41	36	32	25	16	5	1	0
MAY	(3.66)	86	71	62	55	49	43	36	24	3	0	0	0
JUN	(4.04)	91	76	67	59	54	48	39	23	6	1	0	0
JUL													
AUG													
SEP													
OCT													
NOV	(2.84)	79	57	49	47	43	40	32	23	14	0	0	0
DEC	(2.09)	78	60	48	40	33	24	15	6	0	0	0	0

SOLAR RADIATION DATA for: SIDNEY,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	3.52	96	85	74	69	59	49	37	27	11	0	0	0
FEB	(3.51)	93	77	58	50	43	36	31	26	21	7	1	0
MAR	(4.66)	94	83	74	64	55	50	46	37	27	13	1	0
APR	(4.07)	87	74	65	60	47	38	29	20	12	2	0	0
MAY	(3.95)	89	75	61	55	46	37	27	16	1	0	0	0
JUN	(4.45)	94	83	72	63	51	38	26	13	1	0	0	0
JUL	4.59	93	83	74	66	57	45	36	21	1	0	0	0
AUG	(4.87)	95	85	78	71	61	51	41	30	7	0	0	0
SEP	5.65	96	91	86	81	75	68	57	45	30	1	0	0
OCT	(4.21)	93	84	76	68	59	50	42	32	18	2	0	0
NOV	2.83	87	75	62	51	46	37	27	16	1	0	0	0
DEC	(2.83)	82	75	68	63	52	40	30	18	0	0	0	0

SOLAR RADIATION DATA for: SIDNEY,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	3.22	87	76	69	59	52	42	32	20	8	0	0	0
FEB	3.53	83	71	62	55	48	42	32	27	19	3	1	0
MAR	(4.54)	96	88	76	68	60	53	41	31	20	8	1	0
APR													
MAY													
JUN	(4.57)	93	84	77	68	54	44	29	14	0	0	0	0
JUL	4.45	92	82	73	65	54	44	31	10	1	0	0	0
AUG	(4.09)	86	76	68	60	50	39	32	21	6	0	0	0
SEP	4.21	89	78	68	62	56	48	37	27	13	1	0	0
OCT	(4.61)	89	81	76	71	63	54	46	36	22	0	0	0
NOV	3.24	90	78	70	62	53	44	36	23	9	1	0	0
DEC	(2.27)	86	67	61	55	40	32	23	13	2	0	0	0

THIS STATION NOT INSTRUMENTED IN 1977

SOLAR RADIATION DATA for: THOMPSON FALLS,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN													
FEB	(2.21)	74	53	41	34	29	23	18	16	10	2	0	0
MAR	(3.41)	88	69	57	48	43	37	32	27	20	10	3	0
APR	(3.56)	92	77	63	52	44	35	27	17	8	1	0	0
MAY	3.22	90	66	50	41	35	30	24	16	9	4	0	1
JUN	(4.62)	91	82	74	66	56	47	37	26	4	0	0	0
JUL	(4.42)	91	81	73	63	54	45	36	20	2	0	0	0
AUG	(3.42)	75	64	56	48	40	34	27	21	12	2	0	0
SEP													
OCT	(4.47)	94	86	81	76	68	57	47	32	14	1	0	0
NOV	2.02	65	49	39	35	31	25	18	11	4	0	0	0
DEC	(1.39)	53	35	29	25	19	15	13	7	3	1	0	0

SOLAR RADIATION DATA for: THOMPSON FALLS,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.87)	82	71	60	55	48	38	31	22	7	1	0	0
FEB	(1.89)	79	53	36	29	17	14	10	7	4	1	0	0
MAR	4.42	93	80	69	62	58	50	42	33	22	10	1	0
APR	3.90	91	77	65	59	50	40	30	19	10	3	0	0
MAY	(4.12)	91	79	68	57	46	37	26	13	1	0	0	0
JUN	(4.69)	93	86	75	66	57	48	38	25	5	0	0	0
JUL													
AUG													
SEP													
OCT	(3.11)	86	71	59	50	44	36	32	23	10	3	0	0
NOV													
DEC													

SOLAR RADIATION DATA for: THOMPSON FALLS,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(4.03)	95	85	79	71	64	52	41	30	15	0	0	0
FEB	2.13	77	48	38	30	25	18	14	10	6	2	0	0
MAR	(2.68)	86	62	46	37	30	24	17	9	6	2	0	0
APR	(4.58)	94	83	73	63	52	43	35	27	14	0	0	0
MAY													
JUN	(3.97)	89	71	62	50	41	32	27	19	6	0	0	0
JUL	4.57	93	85	76	68	58	47	35	18	1	0	0	0
AUG	(4.63)	93	84	75	66	58	48	36	25	11	1	0	0
SEP	4.02	91	79	70	64	53	43	35	25	12	1	0	0
OCT	3.86	87	75	68	64	59	54	44	31	15	0	0	0
NOV	1.49	64	47	35	28	23	17	13	7	1	0	0	0
DEC	(.67)	31	20	14	12	6	5	3	1	0	0	0	0

SOLAR RADIATION DATA for: WEST YELLOWSTONE,MONTANA 1977

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(4.98)	98	95	86	80	76	67	62	53	40	21	3	0
FEB	5.14	97	89	81	76	69	62	53	43	34	22	4	0
MAR	3.92	95	84	70	56	43	33	25	20	13	7	1	0
APR	(5.17)	91	85	80	73	66	59	48	36	20	3	0	0
MAY	(3.54)	91	78	65	52	40	28	17	9	3	0	0	0
JUN	4.60	94	87	78	70	61	48	37	14	2	0	0	0
JUL	(4.76)	95	87	77	69	58	46	34	21	1	0	0	0
AUG	(3.27)	93	83	55	42	32	22	15	13	6	2	0	0
SEP	(4.77)	92	84	77	67	60	53	46	37	24	5	1	0
OCT	(5.34)	97	93	86	79	70	63	53	39	27	9	0	0
NOV	(2.55)	80	65	50	42	38	31	23	16	10	6	1	0
DEC	(2.09)	72	55	44	41	34	28	24	20	15	7	1	0

SOLAR RADIATION DATA for: WEST YELLOWSTONE,MONTANA 1978

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(1.37)	76	39	22	17	14	13	11	8	6	1	1	0
FEB	(3.30)	91	73	62	50	44	38	32	25	19	13	5	0
MAR	4.81	95	85	75	69	63	55	46	38	26	13	3	0
APR	4.20	95	86	73	60	47	38	29	22	15	4	1	0
MAY	3.76	91	79	64	52	41	33	21	13	3	1	0	0
JUN	4.64	93	86	77	68	59	49	35	12	2	0	0	0
JUL	(4.60)	94	86	78	67	57	48	35	17	1	0	0	0
AUG													
SEP	(5.78)	96	88	83	78	73	67	59	48	36	11	1	0
OCT	5.78	97	94	90	85	78	71	61	51	36	12	0	0
NOV	2.70	80	61	51	45	38	33	28	23	16	4	0	0
DEC	2.88	77	64	55	50	43	38	32	23	12	3	0	0

SOLAR RADIATION DATA for: WEST YELLOWSTONE,MONTANA 1979

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(3.67)	87	72	62	57	52	48	44	36	29	17	2	0
FEB	2.86	90	70	51	43	34	27	22	18	14	10	5	0
MAR	5.10	94	84	74	67	60	53	47	39	31	20	7	2
APR	(5.32)	96	91	85	75	65	56	45	31	17	2	0	0
MAY	(4.91)	94	87	77	66	56	46	37	23	7	1	0	0
JUN	(4.55)	93	85	77	66	56	45	30	12	0	0	0	0
JUL	5.07	95	89	83	75	66	56	44	27	1	0	0	0
AUG	4.49	91	83	75	69	61	52	42	31	12	1	0	0
SEP	6.09	98	95	91	87	80	73	62	50	31	3	0	0
OCT	(4.33)	90	80	73	66	60	52	44	35	23	5	0	0
NOV	(2.33)	66	56	48	42	36	30	27	17	13	9	7	3
DEC	(3.07)	79	62	58	55	51	49	45	32	21	8	0	0

SOLAR RADIATION DATA for: WEST YELLOWSTONE,MONTANA 1980

Montana Department of Natural Resources and Conservation
compiled by: Fowlkes Engineering, Bozeman, Mt.

MONTH	DAILY AVERAGE KWH/SM/DAY	PER CENT TOTAL ENERGY ABOVE THRESHOLD (KW/SM) >.1	>.2	>.3	>.4	>.5	>.6	>.7	>.8	>.9	>1.0	>1.1	>1.2
JAN	(2.36)	73	52	45	42	37	30	25	18	12	3	0	0
FEB	(3.19)	85	64	55	48	41	34	29	24	18	12	4	0
MAR	(3.87)	93	79	63	50	44	37	28	21	16	9	3	0
APR	5.17	96	90	83	76	67	57	43	33	21	5	1	0
MAY	(3.74)	92	79	66	56	45	35	25	13	6	0	0	0
JUN	(4.34)	93	81	71	62	51	42	33	19	2	0	0	0
JUL	4.84	95	88	82	74	66	55	43	26	4	0	0	0
AUG	(5.09)	92	85	79	74	67	58	48	35	15	1	0	0
SEP	(4.79)	95	88	82	74	67	55	49	37	25	8	1	0
OCT	4.56	92	79	72	65	60	54	43	35	24	7	0	0
NOV	2.86	78	60	52	48	43	38	30	21	12	4	0	0
DEC	(2.07)	72	52	45	37	31	24	17	9	3	0	0	0

SECTION VI

MANUAL STATIONS, 1977-1980

RADIATION (kWh/M2) x 317 = RADIATION (BTU/ft^2)

MANUAL SOLAR MEASUREMENT STATION

1977-78 Average Radiation, kWh/m^2-day

STATION	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	SEPT	OCT	NOV	DEC
Baker													2.70
Big Timber			2.08	.63	.82	1.44	1.99	1.74	2.74				
Billings													3.04
Boulder													2.82
Broadus	5.31	5.10	2.82	3.94	3.13	4.81	5.04			2.73	5.03	3.01	2.62
Chester		3.89	3.39	1.95	2.47	3.38	3.86	3.28		5.19	5.06	3.15	2.29
Chinook	4.24	5.83	4.65	2.95	2.28	4.01	5.16	4.09	4.87				
Circle	3.87	5.17	3.30	2.17	2.66	3.77	3.28	5.18	2.90				
Columbus		4.82	3.20	2.33	2.61	2.95	4.76						
Conrad													3.14
Culbertson													2.00
Deer Lodge	4.10	5.15	2.37	1.27		3.08	4.93	4.04	3.35	4.46	4.19	3.43	
Ekalaka	5.05	6.15	3.47	2.93	3.29	4.75	4.65	5.08	4.53	5.67	4.60	3.38	2.07
Forsyth													2.62
Hardin			3.92	2.49	2.93	4.36	6.13	4.49	3.52	6.64	4.75	4.15	
Harlem													2.35
Hobson	4.96	4.38	2.68	1.45	2.59	3.59		5.24	3.78	4.42	4.23	3.60	2.11
Malta		5.61	3.55	2.46	1.74	3.49	3.60	4.28	4.11		3.98	2.44	2.22
Missoula													1.82
Roundup	4.11	5.39	3.33	1.53	1.94	2.87	4.86	5.20	4.55	5.18	4.77	3.17	2.26
Superior	3.04	4.13						3.19			4.24	1.77	
Townsend	6.67	5.44	2.93	1.45	2.54	4.58	5.26	4.76	4.71	4.48	4.78	3.62	1.97
Wh.Sulphur Spgs.		4.02	2.71	1.20	2.25	4.23	4.34	4.85			5.25	3.13	2.12
Winnett	5.87	5.64	4.00	2.44	2.24	3.22	4.82	5.90	5.01				
Wolf Point	5.05	5.79	4.02	2.89	3.63	4.36	5.43	5.54	4.42	4.87	2.83	1.78	

MANUAL SOLAR MEASUREMENT STATION

1979 Average Radiation, kWh/m^2-day

STATION	JAN	FEB	MAR	APR	MAY	SEPT	OCT	NOV	DEC
Baker	4.48	4.53	5.29	3.97	4.55			2.74	2.90
Billings	3.23	2.39	3.21	2.05	3.52				2.77
Boulder	3.30	2.55	4.67	3.16	4.03		2.98	4.10	2.07
Broadus	4.16					5.58		4.52	3.23
Chester	3.50	3.13	4.94	3.87	5.15	4.99	4.11	3.86	1.81
Circle			4.03						
Conrad	2.58		4.57	3.36	4.96	5.33	4.01	3.86	1.80
Deer Lodge	1.90		3.43			4.26	2.90	2.07	1.13
Ekalaka	4.01	4.08	5.13	3.95	5.33	6.68	5.57	3.49	2.73
Eureka			4.11	2.72	4.56	3.51	2.56		
Forsyth	3.62	3.29	3.95	3.76	4.55				
Great Falls	4.35	3.35	4.95	4.01	4.49		3.26	3.39	2.19
Harlem	3.02					5.07	3.48		
Hobson	2.92	2.98	4.74	3.97	4.36				1.61
Malta	2.88	3.46	4.55	3.68	4.44	4.38	4.04	2.87	1.29
Missoula	2.50	1.92	4.39	4.02	6.21			3.8	1.03
Roundup	3.62	3.94	3.38	4.19			4.02	2.94	3.15
Scobey	3.33	3.22							
Superior			3.19						
Townsend	3.20	2.83	4.90	3.88	5.65	5.44	3.42	4.53	2.13
Whitefish	2.42	2.55	3.68	3.83	3.96	4.63	4.32	1.70	.93
Wh.Sulphur Spgs.	3.97	2.82	4.92	3.88		5.51	4.00	3.35	1.39
Wolf Point	2.03	2.43							2.71

MANUAL SOLAR MEASUREMENT STATIONS

1980 Average Radiation, kWh/m^2-day

STATION	JAN	FEB	MAR	APR	MAY	SEPT	OCT	NOV	DEC
Baker	3.63	3.16	4.37	5.21	5.17	5.02	5.11	3.83	2.03
Billings	2.49	2.66	5.23	5.41	5.65	4.44	5.53	2.94	1.97
Boulder	2.65	2.96	3.38	4.96	4.76	4.41	3.64	2.86	2.03
Broadus						4.88	4.39	4.29	2.67
Chester	3.42	3.07	4.05	3.32					
Conrad	2.99								
Deer Lodge	2.34								
Ekalaka	4.02	3.62				4.98	4.35	3.96	2.39
Eureka	2.01	1.25	2.25	3.82	3.48				
Great Falls	3.39								
Hobson	2.34	2.35	3.23	5.52	6.24	3.4		2.69	2.96
Malta	2.39	2.58	3.9	4.41	4.35	3.09	2.79	1.88	1.76
Missoula	3.89	2.15	3.22	3.25	6.13	4.37	4.47	2.41	1.83
Roundup	3.32	3.89	3.79	5.35	5.83	5.84	5.13	2.54	1.55
Townsend	2.94	1.96	3.44	3.95	6.48	5.98	4.22	1.89	1.37
Whitefish	2.13	1.5	3.79	4.24	4.47			.97	1.55
Wh.Sulphur Spgs.	3.14	3.25	5.33	5.92	6.2	5.01	5.86	2.46	1.97
Wolf Point	3.26	3.17	4.83	4.68					

SECTION VII

CLOUDY DAY TOTALS AND OCCURRENCE STATISTICS

alphabetically by station

Note: The total number of data-days during the period are shown in parentheses above each table of occurrence statistics.

TOTALS

ANACONDA CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1978	*	*	*	1	8	0	1	*	5	0	10	10	35*
1979	11	3	*	2	1	0	0	1	*	6	4	7	37
1980	10	3	3	1	4	*	0	0	*	5	8	11	45
AVG	10.5	3.0	3.0	1.3	4.3	.0	.3	.3	5.0	3.7	7.3	9.3	39.0

OCCURRENCE STATISTICS

THIS STATION NOT INSTRUMENTED IN 1977

ANACONDA, 1978

YEAR ROUND(221)									HEATING SEASON(129)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	11	7	4	0	0	0	0	0	8	7	2	0	0	0	0	0

ANACONDA, 1979

YEAR ROUND(313)									HEATING SEASON(200)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	19	5	1	0	1	0	0	0	18	5	1	0	1	0	0	0

ANACONDA, 1980

YEAR ROUND(312)									HEATING SEASON(221)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	20	5	5	0	0	0	0	0	18	5	5	0	0	0	0	0

TOTALS

BILLINGS CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977	*	4	3	1	3	0	0	0	1	2	*	*	20
1978	11	7	2	6	7	0	2	0	*	*	6	7	49
1979	4	2	3	2	3	0	0	1	0	4	6	6	33
1980	7	6	5	1	1	0	0	0	2	5	11	11	49
AVG	7.3	4.8	3.3	2.5	3.5	.0	.5	.3	1.0	3.7	8.3	8.7	38.3

OCCURRENCE STATISTICS

BILLINGS, 1977

YEAR ROUND(291)									HEATING SEASON(165)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	14	5	0	0	0	0	0	0	11	5	0	0	0	0	0	0

BILLINGS, 1978

YEAR ROUND(337)									HEATING SEASON(218)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	16	9	2	1	1	0	0	0	11	9	2	1	1	0	0	0

BILLINGS, 1979

YEAR ROUND(333)									HEATING SEASON(220)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	25	4	1	0	0	0	0	0	24	3	1	0	0	0	0	0

BILLINGS, 1980

YEAR ROUND(351)									HEATING SEASON(217)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	22	8	2	0	1	0	0	0	20	8	2	0	1	0	0	0

TOTALS

BOZEMAN CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977	5	4	2	0	3	1	0	1	4	4	10	16	50
1978	11	2	0	1	3	2	0	0	4	1	9	11	44
1979	13	3	1	1	1	0	0	1	0	6	4	10	40
1980	10	*	1	1	2	2	0	2	4	7	14	10	57
AVG	9.8	3.0	1.0	.8	2.3	1.3	.0	1.0	3.0	4.3	9.3	11.8	47.8

OCCURRENCE STATISTICS

BOZEMAN, 1977

YEAR ROUND(331)									HEATING SEASON(208)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	23	11	1	1	0	0	0	0	19	10	1	1	0	0	0	0

BOZEMAN, 1978

YEAR ROUND(350)									HEATING SEASON(220)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	12	9	6	0	0	0	0	0	8	9	5	0	0	0	0	0

BOZEMAN, 1979

YEAR ROUND(358)									HEATING SEASON(226)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	23	5	3	0	0	0	0	0	20	5	3	0	0	0	0	0

BOZEMAN, 1980

YEAR ROUND(339)									HEATING SEASON(210)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	29	7	2	2	0	0	0	0	19	7	2	2	0	0	0	0

TOTALS

BROWNING CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977	*	*	*	0	1	0	1	*	5	2	7	18	36*
1978	8	1	2	6	4	0	2	3	3	4	*	*	33
1979	*	*	*	1	4	0	2	*	*	5	*	*	15*
1980	*	*	0	*	4	*	*	*	*	4	4	*	16*
AVG	8.0	1.0	1.0	2.3	3.3	.0	1.7	3.0	4.0	3.8	5.5	18.0	25.0

OCCURRENCE STATISTICS

BROWNING, 1977

YEAR ROUND(227)									HEATING SEASON(131)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	9	7	2	2	0	0	0	0	7	5	1	2	0	0	0	0

BROWNING, 1978

YEAR ROUND(287)									HEATING SEASON(154)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	20	4	2	0	0	0	0	0	12	3	2	0	0	0	0	0

BROWNING, 1979

YEAR ROUND(185)									HEATING SEASON(104)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	6	3	1	0	0	0	0	0	6	2	1	0	0	0	0	0

BROWNING, 1980

YEAR ROUND(136)									HEATING SEASON(103)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	9	2	1	0	0	0	0	0	8	2	0	0	0	0	0	0

TOTALS

BUTTE CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977	*	3	3	0	4	1	*	*	*	1	*	17	35*
1978	13	6	1	1	*	*	*	*	*	*	10	11	45*
1979	8	3	3	1	0	0	*	*	0	4	5	6	30
1980	5	5	0	1	4	1	0	0	2	3	4	11	36
AVG	8.7	4.3	1.8	.8	2.7	.7	.0	.0	1.0	2.7	6.3	11.3	36.5

OCCURRENCE STATISTICS

BUTTE, 1977

YEAR ROUND(240)									HEATING SEASON(186)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	16	4	4	0	0	0	0	0	11	3	4	0	0	0	0	0

BUTTE, 1978

YEAR ROUND(199)									HEATING SEASON(199)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	20	6	3	0	1	0	0	0	20	6	3	0	1	0	0	0

BUTTE, 1979

YEAR ROUND(302)									HEATING SEASON(225)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	18	3	0	0	0	1	0	0	18	3	0	0	0	1	0	0

BUTTE, 1980

YEAR ROUND(357)									HEATING SEASON(231)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	21	5	1	1	0	0	0	0	15	5	1	1	0	0	0	0

TOTALS

CHOTEAU CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1978	*	*	*	3	4	0	1	1	4	2	11	11	40
1979	10	4	1	2	1	0	0	*	0	2	4	7	32
1980	6	7	2	0	3	1	0	*	4	4	7	23	58
AVG	8.0	5.5	1.5	1.7	2.7	.3	.3	1.0	2.7	2.7	7.3	13.7	43.3

OCCURRENCE STATISTICS

THIS STATION NOT INSTRUMENTED IN 1977

CHOTEAU, 1978

YEAR ROUND(267)									HEATING SEASON(150)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	22	3	2	0	0	0	1	0	15	2	2	0	0	0	1	0

CHOTEAU, 1979

YEAR ROUND(325)									HEATING SEASON(220)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	20	1	1	0	0	0	1	0	19	1	1	0	0	0	1	0

CHOTEAU, 1980

YEAR ROUND(331)									HEATING SEASON(218)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	29	1	4	0	0	0	0	1	21	1	4	0	0	0	0	1

TOTALS

COLSTRIP CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977	*	*	4	1	2	*	*	*	*	*	*	*	9*
1978	*	*	1	4	4	0	1	1	0	3	7	*	22
1979	*	*	3	4	*	*	*	*	*	*	*	6	22*
1980	8	9	5	1	1	0	0	*	3	4	7	10	48
AVG	8.0	9.0	3.3	2.5	2.3	.0	.5	1.0	1.5	3.5	7.0	8.0	25.3

COLSTRIP, 1977

YEAR ROUND(107)								
CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	7	1	0	0	0	0	0	0

HEATING SEASON(89)							
1	2	3	4	5	6	7	>7
7	1	0	0	0	0	0	0

COLSTRIP, 1978

YEAR ROUND(254)								
CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	10	6	0	0	0	0	0	0

HEATING SEASON(130)							
1	2	3	4	5	6	7	>7
8	5	0	0	0	0	0	0

COLSTRIP, 1979

YEAR ROUND(154)								
CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	14	3	1	0	0	0	0	0

HEATING SEASON(122)							
1	2	3	4	5	6	7	>7
13	3	1	0	0	0	0	0

COLSTRIP, 1980

YEAR ROUND(311)								
CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	31	4	3	0	0	0	0	0

HEATING SEASON(211)							
1	2	3	4	5	6	7	>7
27	4	3	0	0	0	0	0

TOTALS

DILLON CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977	*	0	5	0	1	2	2	6	1	2	6	12	37
1978	8	4	0	1	3	0	0	1	*	0	5	7	30
1979	6	0	1	1	0	0	1	2	0	1	*	5	17
1980	5	3	0	1	3	1	0	*	1	5	8	6	33
AVG	6.3	1.8	1.5	.6	1.6	.6	.6	3.0	.7	2.0	6.3	7.5	29.8

OCCURRENCE STATISTICS

DILLON, 1977

YEAR ROUND(307)									HEATING SEASON(189)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	21	4	1	0	1	0	0	0	15	4	1	0	0	0	0	0

DILLON, 1978

YEAR ROUND(331)									HEATING SEASON(212)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	16	4	2	0	0	0	0	0	14	4	2	0	0	0	0	0

DILLON, 1979

YEAR ROUND(332)									HEATING SEASON(204)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	12	2	0	1	0	0	0	0	11	1	0	1	0	0	0	0

DILLON, 1980

YEAR ROUND(342)									HEATING SEASON(225)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	22	5	1	0	0	0	0	0	18	5	1	0	0	0	0	0

TOTALS

ENNIS CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1978	*	*	0	0	2	1	*	*	*	1	10	9	23*
1979	8	5	0	1	1	0	0	2	0	3	3	11	34
1980	6	4	*	*	1	1	0	1	5	*	*	*	20*
AVG	6.0	4.5	.0	.5	1.3	.7	.0	1.5	2.5	2.0	6.5	10.0	25.7

OCCURRENCE STATISTICS

THIS STATION NOT INSTRUMENTED IN 1977

ENNIS, 1978

YEAR ROUND(208)									HEATING SEASON(165)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	9	4	2	0	0	0	0	0	8	4	2	0	0	0	0	0

ENNIS, 1979

YEAR ROUND(330)									HEATING SEASON(213)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	18	6	0	1	0	0	0	0	17	5	0	1	0	0	0	0

ENNIS, 1980

YEAR ROUND(228)									HEATING SEASON(113)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	12	4	0	0	0	0	0	0	6	3	0	0	0	0	0	0

TOTALS

FORT BENTON CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1978	*	*	2	3	5	*	*	1	*	5	*	12	36*
1979	10	7	1	4	4	0	1	0	0	5	10	11	53
1980	11	*	4	1	2	2	0	0	2	7	10	18	60
AVG	10.5	7.0	2.3	2.7	3.7	1.0	.5	.3	1.0	5.7	10.0	13.7	49.7

OCCURRLNCE STATISTICS

THIS STATION NOT INSTRUMENTED IN 1977

FORT BENTON, 1978

YEAR ROUND(240)									HEATING SEASON(154)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	17	6	1	1	0	0	0	0	15	5	1	1	0	0	0	0

FORT BENTON, 1979

YEAR ROUND(353)									HEATING SEASON(230)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	28	2	3	1	2	0	0	0	26	2	3	1	2	0	0	0

FORT BENTON, 1980

YEAR ROUND(349)									HEATING SEASON(215)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	21	6	3	1	1	0	0	1	16	6	3	1	1	0	0	1

TOTALS

GLASGOW CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977	*	4	2	0	4	0	*	1	7	2	6	15	43
1978	6	3	0	6	2	0	0	1	4	3	9	8	42
1979	2	2	0	3	1	0	*	1	2	2	10	10	33
1980	8	5	1	0	1	1	0	0	1	4	7	13	41
AVG	5.3	3.5	.8	2.3	2.0	.3	.0	.6	3.5	2.6	8.0	11.5	39.8

OCCURRENCE STATISTICS

GLASGOW, 1977

YEAR ROUND(328)									HEATING SEASON(206)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	12	7	4	1	1	0	0	0	8	7	3	1	1	0	0	0

GLASGOW, 1978

YEAR ROUND(345)									HEATING SEASON(217)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	27	6	2	0	0	0	0	0	23	6	1	0	0	0	0	0

GLASGOW, 1979

YEAR ROUND(327)									HEATING SEASON(221)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	20	3	3	0	0	0	0	0	17	3	3	0	0	0	0	0

GLASGOW, 1980

YEAR ROUND(353)									HEATING SEASON(226)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	20	4	2	2	0	0	0	0	18	4	2	2	0	0	0	0

TOTALS

GLENDIVE CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977	*	4	5	0	2	0	*	3	6	6	3	14	43
1978	7	7	1	7	6	1	1	*	2	3	8	*	43
1979	*	*	*	5	1	0	0	1	1	*	*	*	8*
1980	2	*	1	1	1	*	1	*	*	*	5	11	34
AVG	4.5	5.5	2.3	3.3	2.5	.3	.7	2.0	3.0	4.5	5.3	12.5	32.5

OCCURRENCE STATISTICS

GLENDIVE, 1977

YEAR ROUND(304)									HEATING SEASON(202)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	19	8	2	0	1	0	0	0	14	7	2	0	1	0	0	0

GLENDIVE, 1978

YEAR ROUND(279)									HEATING SEASON(185)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	23	4	1	1	0	0	1	0	21	2	1	1	0	0	1	0

GLENDIVE, 1979

YEAR ROUND(159)									HEATING SEASON(47)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	4	2	0	0	0	0	0	0	1	2	0	0	0	0	0	0

GLENDIVE, 1980

YEAR ROUND(252)									HEATING SEASON(176)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	18	3	1	2	0	0	0	0	16	2	1	2	0	0	0	0

TOTALS

GREAT FALLS CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977	*	3	3	0	2	1	0	4	7	5	5	7	41
1978	8	3	4	3	3	0	2	1	4	4	11	7	50
1979	9	3	2	3	2	0	0	1	0	4	6	3	33
1980	6	10	3	1	3	1	0	1	4	7	11	21	68
AVG	7.7	4.6	3.0	1.6	2.5	.5	.5	1.6	3.8	5.0	8.3	9.5	48.0

OCCURRENCE STATISTICS

GREAT FALLS, 1977

YEAR ROUND(328)									HEATING SEASON(194)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	21	2	1	2	1	0	0	0	17	1	0	2	1	0	0	0

GREAT FALLS, 1978

YEAR ROUND(343)									HEATING SEASON(215)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	24	5	4	1	0	0	0	0	19	5	3	1	0	0	0	0

GREAT FALLS, 1979

YEAR ROUND(361)									HEATING SEASON(227)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	24	2	2	0	0	0	0	0	23	2	2	0	0	0	0	0

GREAT FALLS, 1980

YEAR ROUND(362)									HEATING SEASON(228)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	30	4	6	0	0	0	0	1	23	4	6	0	0	0	0	1

TOTALS

HAMILTON CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977	*	*	*	1	1	1	0	*	*	5	12	18	41*
1978	21	7	2	1	2	*	*	*	*	2	13	11	63*
1979	7	8	3	2	0	1	1	*	0	7	6	15	54
1980	12	6	3	1	3	0	*	0	2	3	8	16	54
AVG	14.0	7.0	2.7	1.3	1.5	.7	.5	.0	1.0	4.8	9.8	15.0	53.0

OCCURRENCE STATISTICS

HAMILTON, 1977

YEAR ROUND(324)									HEATING SEASON(146)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	10	4	2	0	1	0	0	1	8	4	2	0	1	0	0	1

HAMILTON, 1978

YEAR ROUND(227)									HEATING SEASON(210)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	15	9	3	3	2	0	0	0	14	9	2	3	2	0	0	0

HAMILTON, 1979

YEAR ROUND(331)									HEATING SEASON(228)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	20	8	2	0	0	1	1	0	18	8	2	0	0	1	1	0

HAMILTON, 1980

YEAR ROUND(328)									HEATING SEASON(224)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	23	6	1	0	0	1	0	1	19	6	1	0	0	1	0	1

TOTALS

HARLOWTON CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977	*	2	1	2	2	*	0	2	3	5	*	12	36
1978	*	4	3	4	3	*	0	0	2	*	*	*	21*
1979	*	2	*	*	2	0	*	*	0	2	6	5	22
1980	10	4	*	*	1	1	0	0	*	6	8	*	36
AVG	10.0	3.0	2.0	3.0	2.0	.5	.0	.7	1.7	4.3	7.0	8.5	28.8

OCCURRENCE STATISTICS

HARLOWTON, 1977

YEAR ROUND(286)								
CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	24	5	0	1	0	0	0	0

HEATING SEASON(183)							
1	2	3	4	5	6	7	>7
18	5	0	1	0	0	0	0

HARLOWTON, 1978

YEAR ROUND(226)								
CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	12	2	1	1	0	0	0	0

HEATING SEASON(124)							
1	2	3	4	5	6	7	>7
9	2	1	1	0	0	0	0

HARLOWTON, 1979

YEAR ROUND(245)								
CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	15	2	1	0	0	0	0	0

HEATING SEASON(151)							
1	2	3	4	5	6	7	>7
14	1	1	0	0	0	0	0

HAVRE, 1980

YEAR ROUND(318)								
CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	24	6	1	1	0	0	0	1

HEATING SEASON(192)							
1	2	3	4	5	6	7	>7
19	6	1	1	0	0	0	1

TOTALS

HAVRE CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977	*	2	2	*	2	1	2	2	6	2	7	9	35
1978	*	4	2	9	3	1	2	*	4	5	10	13	61
1979	1	*	1	4	0	*	*	*	0	4	9	10	36
1980	9	6	3	3	0	2	0	1	2	*	9	12	51
AVG	5.0	4.0	2.0	5.3	1.3	1.3	1.3	1.5	3.0	3.7	8.8	11.5	45.8

OCCURRENCE STATISTICS

HAVRE, 1977

YEAR ROUND(279)

CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	22	3	2	1	0	0	0	0

HEATING SEASON(160)

1	2	3	4	5	6	7	>7
12	3	2	1	0	0	0	0

HAVRE, 1978

YEAR ROUND(304)

CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	28	9	2	1	1	0	0	0

HEATING SEASON(214)

1	2	3	4	5	6	7	>7
23	9	1	1	1	0	0	0

HAVRE, 1979

YEAR ROUND(262)

CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	17	4	4	0	0	0	0	0

HEATING SEASON(209)

1	2	3	4	5	6	7	>7
15	4	4	0	0	0	0	0

HAVRE, 1980

YEAR ROUND(318)

CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	24	6	1	1	0	0	0	1

HEATING SEASON(192)

1	2	3	4	5	6	7	>7
19	6	1	1	0	0	0	1

TOTALS

HELENA CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977	11	3	2	0	2	2	*	2	4	1	9	13	49
1978	13	2	0	1	3	0	0	0	5	1	10	11	46
1979	6	4	1	3	1	0	0	2	0	4	5	7	33
1980	5	7	*	1	3	3	*	*	*	5	7	16	51
AVG	8.8	4.0	1.0	1.3	2.3	1.3	.0	1.3	3.0	2.8	7.8	11.8	44.8

OCCURRENCE STATISTICS

HELENA, 1977

YEAR ROUND(318)									HEATING SEASON(214)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	19	11	1	0	1	0	0	0	17	8	1	0	1	0	0	0

HELENA, 1978

YEAR ROUND(353)									HEATING SEASON(223)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	22	6	4	1	0	0	0	0	18	6	3	1	0	0	0	0

HELENA, 1979

YEAR ROUND(349)									HEATING SEASON(224)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	24	3	1	0	0	0	0	0	22	3	1	0	0	0	0	0

HELENA, 1980

YEAR ROUND(268)									HEATING SEASON(205)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	23	6	2	0	0	0	0	1	16	6	2	0	0	0	0	1

TOTALS

JORDAN CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1978	*	*	*	*	5	0	1	1	4	4	12	12	39*
1979	5	3	3	4	1	*	*	*	0	3	8	*	31
1980	7	7	1	1	0	0	0	*	4	6	6	9	41
AVG	6.0	5.0	2.0	2.5	2.0	.0	.5	1.0	2.7	4.3	8.7	10.5	37.0

OCCURRENCE STATISTICS

THIS STATION NOT INSTRUMENTED IN 1977

JORDAN, 1978

YEAR ROUND(230)									HEATING SEASON(100)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	14	4	2	0	1	1	0	0	11	3	1	0	1	1	0	0

JORDAN, 1979

YEAR ROUND(248)									HEATING SEASON(198)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	21	5	1	0	0	0	0	0	21	5	1	0	0	0	0	0

JORDAN, 1980

YEAR ROUND(332)									HEATING SEASON(226)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	17	10	2	0	0	0	0	0	15	9	2	0	0	0	0	0

TOTALS

KALISPELL CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977	*	7	6	0	1	0	*	3	6	5	9	13	51
1978	22	6	3	2	1	1	0	3	4	2	14	16	74
1979	10	16	2	3	3	0	0	1	0	9	19	27	90
1980	11	*	4	3	2	0	2	2	3	4	15	24	75
AVG	14.3	9.7	3.8	2.0	1.8	.3	.7	2.3	3.3	5.0	14.3	20.0	72.5

OCCURRENCE STATISTICS

KALISPELL, 1977

YEAR ROUND(290)									HEATING SEASON(178)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	31	0	5	2	0	0	0	0	24	0	5	2	0	0	0	0

KALISPELL, 1978

YEAR ROUND(360)									HEATING SEASON(228)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	31	6	5	3	0	1	0	0	21	6	5	3	0	1	0	0

KALISPELL, 1979

YEAR ROUND(356)									HEATING SEASON(223)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	11	8	5	0	4	1	2	1	10	8	5	0	4	1	2	1

KALISPELL, 1980

YEAR ROUND(345)									HEATING SEASON(212)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	21	12	1	1	0	0	0	2	17	9	1	1	0	0	0	2

TOTALS

LEWISTOWN CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977	*	4	0	0	3	0	*	3	5	3	10	7	35
1978	*	6	1	2	3	1	0	*	3	2	*	*	32
1979	6	2	4	2	1	0	0	0	0	4	8	8	35
1980	9	6	2	0	0	1	0	1	4	8	9	13	53
AVG	7.5	4.5	1.8	1.0	1.8	.5	.0	1.3	3.0	4.3	9.0	9.3	38.8

OCCURRENCE STATISTICS

LEWISTOWN, 1977

YEAR ROUND(298)									HEATING SEASON(184)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	23	5	0	1	0	0	0	0	15	5	0	1	0	0	0	0

LEWISTOWN, 1978

YEAR ROUND(258)									HEATING SEASON(168)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	19	4	2	0	0	0	0	0	16	3	2	0	0	0	0	0

LEWISTOWN, 1979

YEAR ROUND(338)									HEATING SEASON(221)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	27	4	0	0	0	0	0	0	27	4	0	0	0	0	0	0

LEWISTOWN, 1980

YEAR ROUND(362)									HEATING SEASON(228)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	28	6	2	0	0	0	1	0	22	6	2	0	0	0	1	0

TOTALS

LIBBY CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977	*	*	2	0	2	0	*	0	5	3	*	*	22*
1978	*	3	6	3	1	0	0	5	4	2	14	14	52
1979	*	15	3	2	2	0	0	1	1	6	19	25	80
1980	14	21	7	0	7	0	2	2	4	9	*	17	93
AVG	14.0	13.0	4.5	1.3	3.0	.0	.7	2.0	3.5	5.5	16.5	18.7	61.8

OCCURRENCE STATISTICS

LIBBY, 1977

YEAR ROUND(224)									HEATING SEASON(131)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	13	5	0	0	0	0	0	0	9	4	0	0	0	0	0	0

LIBBY, 1978

YEAR ROUND(303)									HEATING SEASON(182)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	26	6	1	0	1	1	0	0	17	6	1	0	1	1	0	0

LIBBY, 1979

YEAR ROUND(334)									HEATING SEASON(202)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	14	4	3	2	0	2	0	3	12	4	3	2	0	2	0	3

LIBBY, 1980

YEAR ROUND(339)									HEATING SEASON(207)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	13	13	2	3	1	1	2	1	7	10	2	3	1	1	2	1

TOTALS

LIVINGSTON CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1978	*	*	1	*	6	*	1	*	*	1	*	*	19*
1979	*	*	4	2	*	*	0	*	*	*	*	12	34*
1980	12	6	*	1	3	*	0	*	*	7	8	12	50
AVG	12.0	6.0	2.5	1.5	4.5	.0	.3	.0	.0	4.0	8.0	12.0	34.3

OCCURRENCE STATISTICS

THIS STATION NOT INSTRUMENTED IN 1977

LIVINGSTON, 1978

YEAR ROUND(209)									HEATING SEASON(128)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	11	4	0	0	0	0	0	0	7	4	0	0	0	0	0	0

LIVINGSTON, 1979

YEAR ROUND(172)									HEATING SEASON(136)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	21	2	2	1	0	0	0	0	21	2	2	1	0	0	0	0

LIVINGSTON, 1980

YEAR ROUND(263)									HEATING SEASON(187)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	22	5	3	1	1	0	0	0	19	5	3	1	1	0	0	0

TOTALS

MILESCITY CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977	*	4	3	1	2	*	*	2	6	4	9	12	46
1978	8	3	1	5	5	0	0	*	4	3	13	7	49
1979	0	2	3	4	1	0	*	*	0	2	8	6	26
1980	8	10	3	2	1	1	0	2	2	6	*	8	43
AVG	5.3	4.8	2.5	3.0	2.3	.3	.0	2.0	3.0	3.8	10.0	8.3	41.0

OCCURRENCE STATISTICS

MILES CITY, 1977

YEAR ROUND(309)									HEATING SEASON(208)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	25	7	1	1	0	0	0	0	18	7	1	1	0	0	0	0

MILES CITY, 1978

YEAR ROUND(313)									HEATING SEASON(228)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	24	4	4	0	1	0	0	0	23	3	3	0	1	0	0	0

MILES CITY, 1979

YEAR ROUND(324)									HEATING SEASON(225)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	19	2	1	0	0	0	0	0	18	2	1	0	0	0	0	0

MILES CITY, 1980

YEAR ROUND(363)									HEATING SEASON(229)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	30	5	3	0	1	0	0	0	23	5	3	0	1	0	0	0

TOTALS

MISSOULA CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977	*	8	7	1	2	0	1	4	4	3	9	*	55
1978	16	11	1	0	3	2	1	2	7	0	9	14	66
1979	11	10	6	2	3	2	0	2	0	10	11	15	72
1980	11	12	4	4	4	1	1	0	5	6	15	19	82
AVG	12.7	10.3	4.5	1.8	3.0	1.3	.8	2.0	4.0	4.8	11.0	16.0	68.8

OCCURRENCE STATISTICS

MISSOULA, 1977

YEAR ROUND(317)								
CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	18	7	2	1	1	0	0	1

HEATING SEASON(193)							
1	2	3	4	5	6	7	>7
14	6	1	1	1	0	0	1

MISSOULA, 1978

YEAR ROUND(344)								
CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	23	5	5	2	1	0	1	0

HEATING SEASON(212)							
1	2	3	4	5	6	7	>7
12	5	4	2	1	0	1	0

MISSOULA, 1979

YEAR ROUND(352)								
CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	21	11	3	3	0	0	0	1

HEATING SEASON(218)							
1	2	3	4	5	6	7	>7
19	10	3	3	0	0	0	1

MISSOULA, 1980

YEAR ROUND(363)								
CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	27	9	4	1	1	1	0	1

HEATING SEASON(231)							
1	2	3	4	5	6	7	>7
22	8	3	1	1	1	0	1

TOTALS

PLENTYWOOD CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1978	*	*	1	7	5	2	0	0	*	2	11	13	43
1979	*	3	4	8	3	0	0	0	2	3	8	7	39
1980	6	3	2	1	0	1	0	3	3	4	7	9	39
AVG	6.0	3.0	2.3	5.3	2.7	1.0	.0	1.0	2.5	3.0	8.7	9.7	40.3

OCCURRENCE STATISTICS

THIS STATION NOT INSTRUMENTED IN 1977

PLENTYWOOD, 1978

YEAR ROUND(281)									HEATING SEASON(167)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	15	7	0	1	2	0	0	0	13	5	0	1	2	0	0	0

PLENTYWOOD, 1979

YEAR ROUND(334)									HEATING SEASON(205)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	19	6	3	0	0	0	0	0	17	6	3	0	0	0	0	0

PLENTYWOOD, 1980

YEAR ROUND(354)									HEATING SEASON(221)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	23	9	0	0	0	0	0	0	21	6	0	0	0	0	0	0

TOTALS

POLSON CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977	*	8	5	1	1	0	1	3	4	5	8	*	51
1978	23	6	2	1	2	1	0	3	6	2	15	16	79
1979	*	9	4	2	3	*	*	*	0	9	21	23	80
1980	14	12	6	4	3	1	1	1	4	5	18	21	90
AVG	19.5	8.8	4.3	2.0	2.3	.7	.7	2.3	3.5	5.3	15.5	20.0	75.0

OCCURRENCE STATISTICS

POLSON, 1977

YEAR ROUND(315)									HEATING SEASON(181)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	23	6	4	0	1	0	0	0	18	6	3	0	1	0	0	0

POLSON, 1978

YEAR ROUND(361)									HEATING SEASON(231)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	21	6	2	4	1	2	1	0	14	6	2	3	1	2	1	0

POLSON, 1979

YEAR ROUND(271)									HEATING SEASON(216)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	19	3	2	5	1	3	1	0	18	3	2	5	1	3	1	0

POLSON, 1980

YEAR ROUND(362)									HEATING SEASON(229)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	33	13	2	1	1	1	0	1	26	12	2	1	1	1	0	1

TOTALS

REDLODGE CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1978	*	*	3	5	5	1	2	2	2	0	7	4	33
1979	6	2	3	1	3	0	0	2	0	4	6	5	32
1980	8	2	4	0	1	0	0	1	4	4	10	10	44
AVG	7.0	2.0	3.3	2.0	3.0	.3	.7	1.7	2.0	2.7	7.7	6.3	36.3

OCCURRINCE STATISTICS

THIS STATION NOT INSTRUMENTED IN 1977

RED LODGE, 1978

YEAR ROUND(302)								
CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	13	7	2	0	0	0	0	0

HEATING SEASON(177)							
1	2	3	4	5	6	7	>7
9	5	2	0	0	0	0	0

RED LODGE, 1979

YEAR ROUND(360)								
CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	19	5	2	0	0	0	0	0

HEATING SEASON(229)							
1	2	3	4	5	6	7	>7
18	3	2	0	0	0	0	0

RED LODGE, 1980

YEAR ROUND(364)								
CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	24	8	1	0	0	0	0	0

HEATING SEASON(230)							
1	2	3	4	5	6	7	>7
21	7	1	0	0	0	0	0

TOTALS

SIDNEY CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1978	*	*	1	8	3	*	*	*	*	*	*	13	31*
1979	3	5	2	5	2	0	0	0	1	3	9	7	37
1980	6	6	*	*	*	0	1	3	6	3	7	*	38
AVG	4.5	5.5	1.5	6.5	2.5	.0	.5	1.5	3.5	3.0	8.0	10.0	35.3

OCCURRENCE STATISTICS

THIS STATION NOT INSTRUMENTED IN 1977

SIDNEY, 1978

YEAR ROUND(147)								
CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	12	6	0	2	0	0	0	0

HEATING SEASON(129)							
1	2	3	4	5	6	7	>7
12	5	0	2	0	0	0	0

SIDNEY, 1979

YEAR ROUND(344)								
CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	23	3	2	0	1	0	0	0

HEATING SEASON(220)							
1	2	3	4	5	6	7	>7
22	3	2	0	1	0	0	0

SIDNEY, 1980

YEAR ROUND(257)								
CLOUDY DAYS	1	2	3	4	5	6	7	>7
OCCURENCES	23	6	2	0	0	0	0	0

HEATING SEASON(150)							
1	2	3	4	5	6	7	>7
17	4	2	0	0	0	0	0

TOTALS

THOMPSON FALLS CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1978	*	*	5	1	2	1	2	*	*	3	16	16	56*
1979	6	12	6	3	2	*	*	*	*	*	*	*	32*
1980	*	14	7	1	*	*	1	1	2	7	19	20	74
AVG	6.0	13.0	6.0	1.7	2.0	1.0	1.5	1.0	2.0	5.0	18.5	19.0	54.0

OCCURRENCE STATISTICS

THIS STATION NOT INSTRUMENTED IN 1977

THOMPSON FALLS, 1978

YEAR ROUND(238)									HEATING SEASON(164)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	17	5	3	3	2	0	0	0	13	4	3	3	2	0	0	0

THOMPSON FALLS, 1979

YEAR ROUND(157)									HEATING SEASON(135)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	11	4	3	0	1	0	0	0	11	4	3	0	1	0	0	0

THOMPSON FALLS, 1980

YEAR ROUND(273)									HEATING SEASON(172)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	18	6	5	2	2	0	0	1	13	6	5	2	2	0	0	1

TOTALS

WEST YELLOWSTONE CLOUDY DAYS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1977	*	1	1	2	0	0	*	*	3	0	*	11	25
1978	*	5	1	0	2	0	0	*	*	1	11	12	46
1979	9	6	3	0	0	0	0	2	0	4	*	*	33
1980	15	6	3	0	1	1	0	2	*	4	12	14	61
AVG	12.0	5.0	2.0	.5	.8	.3	.0	2.0	1.5	2.3	11.5	12.3	41.3

OCCURRENCE STATISTICS

WEST YELLOWSTONE, 1977

YEAR ROUND(271)									HEATING SEASON(180)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	16	3	1	0	0	0	0	0	13	3	1	0	0	0	0	0

WEST YELLOWSTONE, 1978

YEAR ROUND(297)									HEATING SEASON(216)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	11	5	5	1	0	0	1	0	9	5	5	1	0	0	1	0

WEST YELLOWSTONE, 1979

YEAR ROUND(309)									HEATING SEASON(184)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	16	9	0	0	0	0	0	0	14	9	0	0	0	0	0	0

WEST YELLOWSTONE, 1980

YEAR ROUND(336)									HEATING SEASON(222)							
CLOUDY DAYS	1	2	3	4	5	6	7	>7	1	2	3	4	5	6	7	>7
OCCURENCES	16	4	2	3	1	1	0	1	12	4	2	3	1	1	0	1

SECTION VIII

CLIMATOLOGICAL DATA

alphabetically by station

Note: There are two data tables for each station; one in degrees Fahrenheit and the other in Celsius. These data are long-term averages reproduced from national weather service records.

CLIMATOLOGICAL DATA FOR

ANACONDA

LAT: 46.12 LONG: 112.95 ELEV: 1620(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-5.4	-2.9	-1.4	4.2	9.3	13.1	18.7	17.8	12.4	7.2	.1	-3.4
DAILY MAXIMUM	-1.6	.4	3.9	9.7	15.3	19.9	26.1	24.9	18.7	12.0	4.2	.2
DAILY MINIMUM	-9.6	-8.3	-5.8	-.9	3.4	7.3	11.5	10.5	6.2	1.6	-4.0	-7.4
EXTREME MAXIMUM	12.2	14.4	19.4	28.9	32.2	35.0	37.2	37.8	33.3	27.8	21.7	15.0
EXTREME MINIMUM	-34.4	-37.2	-27.8	-22.8	-8.3	-4.4	.0	-2.2	-15.0	-22.2	-31.7	-33.9
HEATING DEGREE DAYS(18C)	735	595	613	425	278	163	40	62	191	346	548	675

CLIMATOLOGICAL DATA FOR

ANACONDA

LAT: 46.12 LONG: 112.95 ELEV: 5331(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	22.3	26.7	29.4	39.5	48.8	55.6	65.6	64.1	54.4	44.9	32.1	25.8
DAILY MAXIMUM	29.2	32.8	39.0	49.5	59.5	67.8	79.0	76.9	65.7	53.6	39.5	32.3
DAILY MINIMUM	14.7	17.0	21.5	30.3	38.1	45.1	52.7	50.9	43.1	34.8	24.8	18.6
EXTREME MAXIMUM	54.0	58.0	67.0	84.0	90.0	95.0	99.0	100.0	92.0	82.0	71.0	59.0
EXTREME MINIMUM	-30.0	-35.0	-18.0	-9.0	17.0	24.0	32.0	28.0	5.0	-8.0	-25.0	-29.0
HEATING DEGREE DAYS(65F)	1324	1072	1104	765	502	294	72	112	344	623	987	1215

CLIMATOLOGICAL DATA FOR

BILLINGS

LAT: 45.78 LONG: 108.50 ELEV: 947(M)

TEMPERATURE AVERAGES BY MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
*** DEGREES CELSIUS ***												
DAILY AVERAGE	-4.9	-1.3	1.6	8.3	13.4	17.3	21.9	20.8	15.1	9.8	2.4	-2.3
DAILY MAXIMUM	2.3	5.1	9.0	16.8	21.9	25.4	31.4	30.6	24.9	18.6	9.2	5.2
DAILY MINIMUM	-11.4	-9.6	-5.7	-.1	5.1	8.9	12.3	10.7	5.7	.9	-4.9	-8.3
EXTREME MAXIMUM	22.2	22.8	26.7	32.2	35.0	37.8	42.2	39.4	37.2	32.2	22.8	22.8
EXTREME MINIMUM	-37.2	-35.0	-29.4	-13.9	-10.0	-1.1	3.9	.0	-5.0	-10.6	-33.3	-30.6
HEATING DEGREE DAYS(18C)	720	548	518	301	160	67	6	12	122	263	476	640

CLIMATOLOGICAL DATA FOR

BILLINGS

LAT: 45.78 LONG: 108.50 ELEV: 3117(FT)

TEMPERATURE AVERAGES BY MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
*** DEGREES FAHRENHEIT ***												
DAILY AVERAGE	23.2	29.7	34.9	46.9	56.1	63.2	71.4	69.5	59.1	49.7	36.4	27.8
DAILY MAXIMUM	36.1	41.1	48.2	62.3	71.4	77.8	88.6	87.0	76.9	65.5	48.5	41.3
DAILY MINIMUM	11.5	14.8	21.7	31.9	41.2	48.1	54.1	51.2	42.2	33.6	23.2	17.0
EXTREME MAXIMUM	72.0	73.0	80.0	90.0	95.0	100.0	108.0	103.0	99.0	90.0	73.0	73.0
EXTREME MINIMUM	-35.0	-31.0	-21.0	7.0	14.0	30.0	39.0	32.0	23.0	13.0	-28.0	-23.0
HEATING DEGREE DAYS(65F)	1296	988	933	543	288	121	11	23	221	474	858	1153

CLIMATOLOGICAL DATA FOR

BOZEMAN

LAT: 45.67 LONG: 111.03 ELEV: 1445(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-6.4	-3.4	-1.0	5.6	10.5	14.2	19.1	18.3	13.1	7.8	.1	-3.8
DAILY MAXIMUM	-.7	2.1	5.0	12.1	17.4	21.2	27.5	26.8	20.8	14.8	5.8	1.6
DAILY MINIMUM	-12.2	-9.0	-7.1	-.9	3.6	7.2	10.6	9.7	5.3	.8	-5.6	-9.2
EXTREME MAXIMUM	14.4	16.7	21.1	27.2	31.7	32.8	36.7	37.2	35.0	27.8	21.1	15.0
EXTREME MINIMUM	-37.8	-33.9	-30.6	-16.7	-8.9	-3.3	.0	-1.7	-8.9	-12.8	-32.2	-33.9
HEATING DEGREE DAYS(18C)	762	614	596	377	238	128	25	38	160	322	542	682

CLIMATOLOGICAL DATA FOR

BOZEMAN

LAT: 45.67 LONG: 111.03 ELEV: 4754(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	20.4	25.9	30.2	42.1	50.9	57.6	66.3	64.9	55.6	46.1	32.2	25.2
DAILY MAXIMUM	30.7	35.8	41.0	53.7	63.3	70.2	81.5	80.3	69.5	58.7	42.4	34.9
DAILY MINIMUM	10.1	15.8	19.2	30.4	38.5	44.9	51.1	49.4	41.5	33.4	21.9	15.5
EXTREME MAXIMUM	58.0	62.0	70.0	81.0	89.0	91.0	98.0	99.0	95.0	82.0	70.0	59.0
EXTREME MINIMUM	-36.0	-29.0	-23.0	2.0	16.0	26.0	32.0	29.0	16.0	9.0	-26.0	-29.0
HEATING DEGREE DAYS(65F)	1372	1106	1074	680	429	232	45	70	288	581	976	1229

CLIMATOLOGICAL DATA FOR

BROWNING

LAT: 48.55 LONG: 113.02 ELEV: 1356(M)

TEMPERATURE AVERAGES BY MONTH						*** DEGREES CELSIUS ***					
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE											
-7.8	-4.7	-2.8	3.7	9.0	12.6	16.8	15.8	11.3	6.7	-.7	-4.7
DAILY MAXIMUM											
-1.7	-.5	3.4	10.6	16.4	20.0	25.6	24.4	18.5	12.6	4.5	.4
DAILY MINIMUM											
-13.1	-12.2	-8.8	-2.9	1.8	5.1	7.6	6.5	2.8	-1.1	-6.9	-10.3
EXTREME MAXIMUM											
19.9	20.0	22.2	32.8	33.9	36.7	37.2	36.7	34.4	28.3	22.2	20.6
EXTREME MINIMUM											
-48.9	-43.3	-38.9	-25.6	-17.2	-6.1	-4.4	-5.0	-14.8	-27.2	-39.4	-43.9
HEATING DEGREE DAYS(18C)											
809	643	654	438	289	175	61	92	219	360	571	715

CLIMATOLOGICAL DATA FOR

BROWNING

LAT: 48.55 LONG: 113.02 ELEV: 4462(FT)

TEMPERATURE AVERAGES BY MONTH						*** DEGREES FAHRENHEIT ***					
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE											
18.0	23.6	27.0	38.7	48.2	54.7	62.3	60.5	52.3	44.1	30.7	23.5
DAILY MAXIMUM											
29.0	31.1	38.1	51.0	61.5	68.0	78.0	76.0	65.3	54.6	40.1	32.8
DAILY MINIMUM											
8.4	10.1	16.2	26.9	35.3	41.2	45.6	43.7	37.0	30.1	19.5	13.4
EXTREME MAXIMUM											
66.0	68.0	72.0	91.0	93.0	98.0	99.0	98.0	94.0	83.0	72.0	69.0
EXTREME MINIMUM											
-56.0	-46.0	-38.0	-14.0	1.0	21.0	24.0	23.0	.0	-17.0	-39.0	-47.0
HEATING DEGREE DAYS(65F)											
1457	1159	1178	789	521	315	111	167	395	648	1029	1287

CLIMATOLOGICAL DATA FOR

BUTTE

LAT: 46.00 LONG: 112.50 ELEV: 1749(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-9.4	-6.2	-3.6	3.2	8.2	12.2	16.8	15.7	10.3	5.1	-2.3	-7.1
DAILY MAXIMUM	-2.3	.4	3.9	10.5	15.9	19.9	26.7	25.6	19.7	13.5	4.6	.3
DAILY MINIMUM	-16.9	-14.7	-10.2	-3.5	.8	4.5	7.3	5.8	1.6	-2.9	-9.4	-13.5
EXTREME MAXIMUM	12.2	15.6	17.8	26.1	31.1	33.9	37.8	37.2	32.8	28.3	20.0	16.7
EXTREME MINIMUM	-44.4	-46.7	-37.8	-25.0	-11.1	-5.0	-1.7	-3.3	-11.1	-28.3	-41.1	-38.3
HEATING DEGREE DAYS(18C)	859	686	678	455	313	187	66	92	242	411	618	788

CLIMATOLOGICAL DATA FOR

BUTTE

LAT: 46.00 LONG: 112.50 ELEV: 5755(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	15.1	20.9	25.6	37.7	46.8	53.9	62.2	60.3	50.6	41.1	27.9	19.2
DAILY MAXIMUM	27.8	32.7	39.1	50.9	60.7	67.9	80.0	78.0	67.5	56.3	40.3	32.5
DAILY MINIMUM	1.5	5.5	13.7	25.7	33.5	40.1	45.1	42.5	34.8	26.8	15.0	7.7
EXTREME MAXIMUM	54.0	60.0	64.0	79.0	88.0	93.0	100.0	99.0	91.0	83.0	68.0	62.0
EXTREME MINIMUM	-48.0	-52.0	-36.0	-13.0	12.0	23.0	29.0	26.0	12.0	-19.0	-42.0	-37.0
HEATING DEGREE DAYS(65F)	1547	1235	1221	819	564	337	119	166	437	741	1113	1420

CLIMATOLOGICAL DATA FOR

CHOTEAU

LAT: 47.82 LONG: 112.20 ELEV: 1155(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-6.1	-2.9	-.8	5.7	10.9	14.8	19.1	18.0	12.8	8.3	1.0	-3.1
DAILY MAXIMUM	.7	2.6	6.6	12.9	18.6	22.4	28.2	27.1	20.9	15.5	7.4	3.6
DAILY MINIMUM	-13.2	-11.8	-7.7	-2.2	2.7	6.8	9.6	7.9	3.7	-.5	-6.6	-9.6
EXTREME MAXIMUM	18.9	21.1	27.8	29.4	33.3	36.1	40.6	41.1	35.6	30.6	25.0	22.2
EXTREME MINIMUM	-42.2	-45.6	-37.8	-26.7	-13.3	-2.2	.6	-1.7	-20.6	-26.1	-34.4	-38.9
HEATING DEGREE DAYS(18C)	756	595	594	378	230	117	26	47	177	310	520	665

CLIMATOLOGICAL DATA FOR

CHOTEAU

LAT: 47.82 LONG: 112.20 ELEV: 3800(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	21.1	26.7	30.5	42.3	51.6	58.7	66.3	64.4	55.0	47.0	33.8	26.4
DAILY MAXIMUM	33.2	36.6	43.8	55.2	65.4	72.3	82.7	80.8	69.6	59.9	45.4	38.4
DAILY MINIMUM	8.2	10.8	18.2	28.0	36.9	44.2	49.2	46.3	38.7	31.1	20.1	14.8
EXTREME MAXIMUM	66.0	70.0	82.0	85.0	92.0	97.0	105.0	106.0	96.0	87.0	77.0	72.0
EXTREME MINIMUM	-44.0	-50.0	-36.0	-16.0	8.0	28.0	33.0	29.0	-5.0	-15.0	-30.0	-38.0
HEATING DEGREE DAYS(65F)	1361	1072	1070	681	415	212	47	85	320	558	936	1197

CLIMATOLOGICAL DATA FOR

COLSTRIP

LAT: 45.88 LONG: 106.63 ELEV: 772(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-6.1	-2.8	.2	7.1	12.4	17.1	21.9	21.2	15.0	9.2	1.3	-3.6
DAILY MAXIMUM	1.2	4.3	7.7	15.2	20.7	25.3	31.8	31.2	24.4	18.2	8.6	3.4
DAILY MINIMUM	-13.5	-10.1	-7.3	-1.1	4.1	8.7	12.1	11.2	5.6	.2	-6.1	-10.7
EXTREME MAXIMUM	19.4	21.1	26.7	30.6	35.6	38.9	41.7	43.9	38.9	34.4	26.1	21.7
EXTREME MINIMUM	-40.0	-35.0	-33.3	-16.1	-10.6	-2.2	1.1	.6	-7.8	-13.9	-35.6	-37.2
HEATING DEGREE DAYS(18C)	753	585	556	346	177	58	6	13	112	277	508	667

CLIMATOLOGICAL DATA FOR

COLSTRIP

LAT: 45.88 LONG: 106.63 ELEV: 2540(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	21.0	26.9	32.3	44.7	54.3	62.7	71.5	70.1	59.0	48.6	34.3	25.5
DAILY MAXIMUM	34.2	39.8	45.8	59.3	69.2	77.6	89.2	88.1	75.9	64.8	47.5	38.2
DAILY MINIMUM	7.7	13.9	18.9	30.1	39.4	47.7	53.8	52.1	42.0	32.4	21.1	12.8
EXTREME MAXIMUM	67.0	70.0	80.0	87.0	96.0	102.0	107.0	111.0	102.0	94.0	79.0	71.0
EXTREME MINIMUM	-40.0	-31.0	-28.0	3.0	13.0	28.0	34.0	33.0	18.0	7.0	-32.0	-35.0
HEATING DEGREE DAYS(65F)	1356	1053	1001	624	319	105	12	24	203	500	915	1202

CLIMATOLOGICAL DATA FOR

DILLON

LAT: 45.25 LONG: 112.63 ELEV: 1537(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-5.4	-2.6	-.3	5.6	10.4	14.2	18.4	17.4	12.6	7.8	.8	-3.5
DAILY MAXIMUM	1.2	3.5	7.3	13.3	18.6	23.2	28.1	27.3	21.9	16.3	8.1	2.9
DAILY MINIMUM	-11.3	-9.3	-5.8	-1.2	2.7	5.9	8.7	7.3	2.9	-.7	-5.8	-9.4
EXTREME MAXIMUM	15.6	18.3	23.3	28.9	32.8	34.4	37.2	37.8	33.9	30.0	26.1	18.3
EXTREME MINIMUM	-37.8	-40.0	-32.2	-18.3	-9.4	-3.9	-1.1	-3.9	-12.8	-25.0	-35.0	-37.2
HEATING DEGREE DAYS(18C)	737	585	577	381	246	130	27	55	177	325	525	676

CLIMATOLOGICAL DATA FOR

DILLON

LAT: 45.25 LONG: 112.63 ELEV: 5057(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	22.2	27.4	31.5	42.1	50.7	57.5	65.1	63.4	54.7	46.1	33.5	25.7
DAILY MAXIMUM	34.2	38.3	45.2	55.9	65.4	73.8	82.6	81.1	71.4	61.4	46.5	37.2
DAILY MINIMUM	11.7	15.3	21.5	29.9	36.9	42.7	47.7	45.1	37.2	30.7	21.5	15.1
EXTREME MAXIMUM	60.0	65.0	74.0	84.0	91.0	94.0	99.0	100.0	93.0	86.0	79.0	65.0
EXTREME MINIMUM	-36.0	-40.0	-26.0	-1.0	15.0	25.0	30.0	25.0	9.0	-13.0	-31.0	-35.0
HEATING DEGREE DAYS(65F)	1327	1053	1039	687	443	235	50	100	319	586	945	1218

CLIMATOLOGICAL DATA FOR

ENNIS

LAT: 45.35 LONG: 111.73 ELEV: 1492(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-5.2	-2.5	-.4	5.4	10.2	13.9	18.2	17.3	12.3	7.7	1.0	-2.9
DAILY MAXIMUM	-.1	2.2	6.3	13.0	18.6	22.9	28.2	27.2	21.7	15.3	6.7	2.0
DAILY MINIMUM	-11.3	-9.6	-6.5	-2.1	2.1	5.7	8.5	7.2	3.1	-.6	-5.6	-8.6
EXTREME MAXIMUM	14.4	16.7	24.4	27.8	34.4	36.1	37.8	36.1	33.3	30.0	21.7	20.0
EXTREME MINIMUM	-41.7	-41.7	-33.9	-21.7	-9.4	-4.4	.0	-2.8	-11.1	-23.3	-32.8	-38.3
HEATING DEGREE DAYS(18C)	730	583	580	386	251	138	37	52	186	330	520	657

CLIMATOLOGICAL DATA FOR

ENNIS

LAT: 45.35 LONG: 111.73 ELEV: 4927(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	22.6	27.5	31.3	41.8	50.4	57.0	64.7	63.1	54.1	45.8	33.8	26.8
DAILY MAXIMUM	31.8	36.0	43.4	55.4	65.5	73.3	82.8	81.0	71.0	59.5	44.0	35.6
DAILY MINIMUM	11.6	14.7	20.3	28.3	35.8	42.3	47.3	44.9	37.5	30.9	21.9	16.5
EXTREME MAXIMUM	58.0	62.0	76.0	82.0	94.0	97.0	100.0	97.0	92.0	86.0	71.0	68.0
EXTREME MINIMUM	-43.0	-43.0	-29.0	-7.0	15.0	24.0	32.0	27.0	12.0	-10.0	-27.0	-37.0
HEATING DEGREE DAYS(65F)	1314	1050	1045	696	453	249	68	94	336	595	936	1184

CLIMATOLOGICAL DATA FOR

FORT BENTON

LAT: 47.80 LONG: 110.67 ELEV: 790(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-7.3	-3.3	-.1	7.3	12.8	16.7	20.9	20.0	14.1	8.9	.9	-4.3
DAILY MAXIMUM	.1	1.6	6.6	15.4	20.2	23.8	29.6	28.5	22.6	17.1	7.2	3.1
DAILY MINIMUM	-12.9	-12.0	-7.1	-.3	4.9	9.2	11.9	10.5	5.7	.7	-5.6	-9.4
EXTREME MAXIMUM	22.2	21.1	27.8	33.9	34.4	42.2	43.9	42.8	38.3	33.3	25.6	22.8
EXTREME MINIMUM	-50.0	-42.8	-41.1	-21.1	-10.0	-2.8	-.6	-2.8	-12.8	-21.1	-37.8	-50.6
HEATING DEGREE DAYS(18C)	806	605	571	330	176	78	8	18	140	294	523	701

CLIMATOLOGICAL DATA FOR

FORT BENTON

LAT: 47.80 LONG: 110.67 ELEV: 2600(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	18.8	26.1	31.8	45.2	55.0	62.0	69.7	68.0	57.3	47.9	33.6	24.3
DAILY MAXIMUM	32.1	34.9	43.9	59.7	68.4	74.9	85.3	83.3	72.7	62.7	45.0	37.6
DAILY MINIMUM	8.7	10.4	19.2	31.5	40.9	48.6	53.4	50.9	42.2	33.2	21.9	15.1
EXTREME MAXIMUM	72.0	70.0	82.0	93.0	94.0	108.0	111.0	109.0	101.0	92.0	78.0	73.0
EXTREME MINIMUM	-58.0	-45.0	-42.0	-6.0	14.0	27.0	31.0	27.0	9.0	-6.0	-36.0	-59.0
HEATING DEGREE DAYS(65F)	1451	1089	1029	594	317	141	16	33	253	530	942	1262

CLIMATOLOGICAL DATA FOR

GLASGOW

LAT: 48.20 LONG: 106.63 ELEV: 636(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-11.9	-9.7	-2.0	6.9	13.1	17.6	22.3	20.5	14.0	7.5	-2.2	-9.0
DAILY MAXIMUM	-6.9	-4.6	3.0	13.2	20.2	24.4	30.4	28.6	21.4	14.4	3.3	-3.9
DAILY MINIMUM	-17.0	-14.9	-7.0	.6	5.9	10.7	14.2	12.4	6.6	.6	-7.8	-14.1
EXTREME MAXIMUM	16.1	15.0	25.6	33.9	38.9	36.1	42.2	42.2	38.9	35.6	21.1	17.8
EXTREME MINIMUM	-45.6	-36.1	-33.9	-20.0	-8.9	2.2	3.9	.6	-6.1	-13.9	-29.4	-35.0
HEATING DEGREE DAYS(18C)	938	785	630	343	183	72	8	18	145	336	616	847

CLIMATOLOGICAL DATA FOR

GLASGOW

LAT: 48.20 LONG: 106.63 ELEV: 2095(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	10.5	14.5	28.4	44.4	55.5	63.6	72.2	68.9	57.2	45.5	28.0	15.8
DAILY MAXIMUM	19.6	23.7	37.4	55.7	68.4	75.9	86.7	83.5	70.5	57.9	37.9	24.9
DAILY MINIMUM	1.4	5.2	19.4	33.0	42.6	51.2	57.6	54.3	43.8	33.1	18.0	6.6
EXTREME MAXIMUM	61.0	59.0	78.0	93.0	102.0	97.0	108.0	108.0	102.0	96.0	70.0	64.0
EXTREME MINIMUM	-50.0	-33.0	-29.0	-4.0	16.0	36.0	39.0	33.0	21.0	7.0	-21.0	-31.0
HEATING DEGREE DAYS(65F)	1690	1414	1135	618	330	131	15	34	262	605	1110	1525

CLIMATOLOGICAL DATA FOR

GLENDIVE

LAT: 47.12 LONG: 104.73 ELEV: 629(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-9.5	-6.4	-.9	8.0	14.3	18.8	23.3	22.3	15.7	9.7	.6	-5.6
DAILY MAXIMUM	-3.7	-1.8	5.2	15.5	21.8	26.4	31.8	30.7	23.8	16.7	6.1	-.6
DAILY MINIMUM	-16.1	-14.8	-8.1	.3	6.1	11.3	14.6	12.8	6.7	.6	-6.6	-12.5
EXTREME MAXIMUM	17.2	22.8	29.4	35.6	40.0	42.8	47.2	45.0	40.0	35.0	24.4	22.2
EXTREME MINIMUM	-44.4	-45.6	-36.7	-21.1	-8.9	-1.7	2.2	.0	-8.9	-25.0	-42.2	-40.0
HEATING DEGREE DAYS(18C)	862	692	596	313	136	50	4	7	113	268	531	742

CLIMATOLOGICAL DATA FOR

GLENDIVE

LAT: 47.12 LONG: 104.73 ELEV: 2071(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	14.9	20.5	30.4	46.4	57.8	65.9	74.0	72.2	60.2	49.4	33.1	21.9
DAILY MAXIMUM	25.3	28.8	41.4	59.9	71.3	79.6	89.2	87.3	74.9	62.1	43.0	31.0
DAILY MINIMUM	3.0	5.3	17.4	32.5	43.0	52.3	58.2	55.0	44.1	33.0	20.2	9.5
EXTREME MAXIMUM	63.0	73.0	85.0	96.0	104.0	109.0	117.0	113.0	104.0	95.0	76.0	72.0
EXTREME MINIMUM	-48.0	-50.0	-34.0	-6.0	16.0	29.0	36.0	32.0	16.0	-13.0	-26.0	-40.0
HEATING DEGREE DAYS(65F)	1553	1246	1073	564	246	90	8	13	204	484	957	1336

CLIMATOLOGICAL DATA FOR

GREAT FALLS

LAT: 47.52 LONG: 111.30 ELEV: 1012(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE											
-6.4	-3.0	-.8	6.3	11.8	16.0	20.7	19.7	14.1	9.1	1.4	-3.1
DAILY MAXIMUM											
-1.5	2.2	4.7	12.5	18.3	22.3	28.7	27.7	21.1	15.2	6.3	1.5
DAILY MINIMUM											
-11.3	-8.2	-6.3	.2	5.3	9.7	12.7	11.7	7.0	2.8	-3.5	-7.7
EXTREME MAXIMUM											
16.1	17.8	22.2	28.3	32.2	36.1	40.6	41.1	36.7	29.4	22.2	16.1
EXTREME MINIMUM											
-38.3	-30.0	-28.3	-15.0	-7.2	.0	4.4	2.8	-5.0	-19.4	-26.1	-41.7
HEATING DEGREE DAYS(18C)											
766	597	594	360	203	90	10	23	144	291	506	663

CLIMATOLOGICAL DATA FOR

GREAT FALLS

LAT: 47.52 LONG: 111.30 ELEV: 3330(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE											
20.5	26.6	30.5	43.4	53.3	60.8	69.3	67.4	57.3	48.3	34.6	26.5
DAILY MAXIMUM											
29.3	35.9	40.4	54.5	65.0	72.1	83.7	81.8	70.0	59.4	43.4	34.7
DAILY MINIMUM											
11.6	17.2	20.6	32.3	41.5	49.5	54.9	53.0	44.6	37.1	25.7	18.2
EXTREME MAXIMUM											
61.0	64.0	72.0	83.0	90.0	97.0	105.0	106.0	98.0	85.0	72.0	61.0
EXTREME MINIMUM											
-37.0	-22.0	-19.0	5.0	19.0	32.0	40.0	37.0	23.0	-3.0	-15.0	-43.0
HEATING DEGREE DAYS(65F)											
1380	1075	1070	648	367	162	18	42	260	524	912	1194

CLIMATOLOGICAL DATA FOR

HAMILTON

LAT: 46.25 LONG: 114.15 ELEV: 1094(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-4.0	-.4	2.3	7.6	11.9	15.4	19.7	18.6	13.7	8.1	1.6	-2.3
DAILY MAXIMUM	1.3	4.1	9.2	15.6	20.2	23.9	29.6	28.4	22.3	15.6	7.6	2.6
DAILY MINIMUM	-9.1	-7.1	-3.2	.7	4.3	7.6	10.4	9.3	5.4	.9	-3.8	-7.2
EXTREME MAXIMUM	16.7	21.7	23.3	32.2	38.9	37.8	39.4	38.9	36.7	32.2	22.2	18.9
EXTREME MINIMUM	-37.8	-39.4	-25.6	-17.2	-7.8	-1.7	.6	.0	-7.8	-18.3	-41.1	-44.4
HEATING DEGREE DAYS(18C)	692	525	496	321	201	95	15	36	148	318	503	638

CLIMATOLOGICAL DATA FOR

HAMILTON

LAT: 46.25 LONG: 114.15 ELEV: 3600(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	24.8	31.2	36.2	45.7	53.5	59.8	67.5	65.5	56.7	46.5	34.8	27.9
DAILY MAXIMUM	34.4	39.3	48.6	60.0	68.4	75.1	85.2	83.1	72.2	60.0	45.6	36.6
DAILY MINIMUM	15.7	19.2	26.2	33.2	39.7	45.7	50.8	48.8	41.7	33.6	25.2	19.1
EXTREME MAXIMUM	62.0	71.0	74.0	90.0	102.0	100.0	103.0	102.0	98.0	90.0	72.0	66.0
EXTREME MINIMUM	-36.0	-39.0	-14.0	1.0	18.0	29.0	33.0	32.0	18.0	-1.0	-24.0	-30.0
HEATING DEGREE DAYS(65F)	1246	946	893	579	362	171	27	66	267	574	906	1150

CLIMATOLOGICAL DATA FOR

HARLOWTON

LAT: 46.43 LONG: 109.83 ELEV: 1266(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-5.7	-3.6	-1.0	5.6	10.7	14.2	18.9	17.6	12.5	7.8	.4	-2.9
DAILY MAXIMUM	.9	3.3	6.3	13.6	19.1	22.3	28.5	27.7	21.9	16.4	7.6	3.5
DAILY MINIMUM	-12.3	-10.6	-8.3	-2.4	2.3	6.1	9.2	7.4	3.1	-.7	-6.7	-9.4
EXTREME MAXIMUM	17.2	23.3	24.4	30.6	33.9	35.0	38.9	38.3	36.1	32.8	25.6	20.6
EXTREME MINIMUM	-38.9	-39.4	-34.4	-22.2	-15.6	-4.4	.6	-1.7	-12.2	-15.0	-33.9	-39.4
HEATING DEGREE DAYS(18C)	745	601	604	394	235	115	25	45	177	311	533	658

CLIMATOLOGICAL DATA FOR

HARLOWTON

LAT: 46.43 LONG: 109.83 ELEV: 4167(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	21.7	25.5	30.2	42.1	51.3	57.6	66.0	63.6	54.5	46.1	32.8	26.7
DAILY MAXIMUM	33.6	38.0	43.4	56.5	66.4	72.2	83.3	81.8	71.4	61.5	45.6	38.3
DAILY MINIMUM	9.8	12.9	17.0	27.7	36.2	43.0	48.6	45.3	37.5	30.7	20.0	15.0
EXTREME MAXIMUM	63.0	74.0	76.0	87.0	93.0	95.0	102.0	101.0	97.0	91.0	78.0	69.0
EXTREME MINIMUM	-38.0	-39.0	-30.0	-8.0	4.0	24.0	33.0	29.0	10.0	5.0	-29.0	-39.0
HEATING DEGREE DAYS(65F)	1342	1083	1088	710	424	207	46	82	319	561	961	1186

CLIMATOLOGICAL DATA FOR

HAVRE

LAT: 48.57 LONG: 109.67 ELEV: 755(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-8.8	-7.3	-.9	7.3	13.2	17.2	21.8	20.0	13.9	8.2	-.6	-6.4
DAILY MAXIMUM	-3.2	-1.3	5.0	14.2	20.4	24.0	29.9	28.3	21.7	15.4	5.3	-.9
DAILY MINIMUM	-14.4	-13.3	-6.9	.3	5.9	10.3	13.7	11.7	6.1	.9	-6.6	-12.1
EXTREME MAXIMUM	18.3	21.7	25.0	35.0	36.7	41.7	41.7	41.1	36.7	32.8	23.3	21.7
EXTREME MINIMUM	-49.4	-44.4	-35.6	-22.2	-10.0	-1.7	2.8	-2.8	-7.8	-21.7	-33.3	-37.8
HEATING DEGREE DAYS(18C)	840	717	597	331	173	69	11	21	150	313	568	768

CLIMATOLOGICAL DATA FOR

HAVRE

LAT: 48.57 LONG: 109.67 ELEV: 2486(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	16.2	18.9	30.3	45.1	55.7	62.9	71.3	68.0	57.0	46.8	30.9	20.4
DAILY MAXIMUM	26.3	29.6	41.0	57.6	68.8	75.2	85.9	82.9	71.0	59.8	41.5	30.4
DAILY MINIMUM	6.1	8.1	19.5	32.5	42.6	50.6	56.6	53.1	42.9	33.7	20.2	10.3
EXTREME MAXIMUM	65.0	71.0	77.0	95.0	98.0	107.0	107.0	106.0	98.0	91.0	74.0	71.0
EXTREME MINIMUM	-57.0	-48.0	-32.0	-8.0	14.0	29.0	37.0	27.0	18.0	-7.0	-28.0	-36.0
HEATING DEGREE DAYS(65F)	1513	1291	1076	597	313	125	20	38	270	564	1023	1383

CLIMATOLOGICAL DATA FOR

HELENA

LAT: 46.58 LONG: 112.03 ELEV: 1253(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-7.4	-4.9	-.3	6.3	11.6	15.3	20.2	19.0	13.3	7.6	-.2	-4.3
DAILY MAXIMUM	-1.8	.9	5.8	13.4	18.8	22.4	29.1	27.9	21.6	14.9	5.8	1.2
DAILY MINIMUM	-13.1	-10.7	-6.6	-.8	4.4	8.1	11.3	10.1	5.1	.2	-6.2	-9.9
EXTREME MAXIMUM	10.0	15.6	21.1	24.4	30.0	31.1	35.0	35.0	32.8	29.4	19.4	15.0
EXTREME MINIMUM	-21.7	-23.9	-26.7	-11.1	-2.8	2.2	5.6	4.4	-7.2	-6.1	-19.4	-38.9
HEATING DEGREE DAYS(18C)	798	650	578	361	211	108	17	32	163	333	556	702

CLIMATOLOGICAL DATA FOR

HELENA

LAT: 46.58 LONG: 112.03 ELEV: 4124(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	18.6	23.2	31.4	43.3	52.9	59.5	68.4	66.2	56.0	45.6	31.6	24.2
DAILY MAXIMUM	28.8	33.7	42.5	56.1	65.8	72.3	84.4	82.2	70.8	58.8	42.4	34.2
DAILY MINIMUM	8.4	12.7	20.2	30.5	39.9	46.6	52.3	50.1	41.2	32.3	20.8	14.2
EXTREME MAXIMUM	50.0	60.0	70.0	76.0	86.0	88.0	95.0	95.0	91.0	85.0	67.0	59.0
EXTREME MINIMUM	-7.0	-11.0	-16.0	12.0	27.0	36.0	42.0	40.0	19.0	21.0	-3.0	-38.0
HEATING DEGREE DAYS(65F)	1438	1170	1042	651	381	195	31	59	294	601	1002	1265

CLIMATOLOGICAL DATA FOR

JORDAN

LAT: 47.32 LONG: 106.90 ELEV: 851(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-9.5	-5.8	-1.3	6.9	12.8	17.5	22.3	21.2	14.6	8.5	-.1	-6.0
DAILY MAXIMUM	-2.2	-.2	6.2	15.0	21.1	25.9	32.4	30.9	24.4	17.0	7.1	1.3
DAILY MINIMUM	-16.3	-15.1	-8.4	-1.3	4.4	9.3	12.9	11.2	5.1	-.9	-7.8	-12.9
EXTREME MAXIMUM	16.7	22.2	27.2	34.4	38.9	43.9	44.4	43.3	41.7	33.9	24.4	21.7
EXTREME MINIMUM	-46.1	-50.0	-37.2	-25.0	-12.2	-1.7	-.6	.0	-7.8	-25.6	-35.0	-39.4
HEATING DEGREE DAYS(18C)	862	675	609	341	175	70	7	12	133	305	551	754

CLIMATOLOGICAL DATA FOR

JORDAN

LAT: 47.32 LONG: 106.90 ELEV: 2800(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	14.9	21.6	29.6	44.5	55.1	63.5	72.1	70.1	58.2	47.3	31.9	21.2
DAILY MAXIMUM	28.1	31.7	43.2	59.0	70.0	78.6	90.3	87.7	75.9	62.6	44.8	34.4
DAILY MINIMUM	2.7	4.8	16.8	29.6	40.0	48.8	55.3	52.1	41.1	30.3	17.9	8.7
EXTREME MAXIMUM	62.0	72.0	81.0	94.0	102.0	111.0	112.0	110.0	107.0	93.0	76.0	71.0
EXTREME MINIMUM	-51.0	-58.0	-35.0	-13.0	10.0	29.0	31.0	32.0	18.0	-14.0	-31.0	-39.0
HEATING DEGREE DAYS(65F)	1553	1215	1097	615	316	127	14	22	240	549	993	1358

CLIMATOLOGICAL DATA FOR

KALISPELL

LAT: 48.22 LONG: 114.27 ELEV: 899(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-6.5	-3.9	.9	6.5	11.3	14.7	18.9	17.8	12.5	6.9	.0	-4.1
DAILY MAXIMUM	-2.2	1.2	6.2	12.9	18.3	21.9	27.8	26.9	20.5	13.2	3.9	-.4
DAILY MINIMUM	-10.8	-9.0	-4.4	.1	4.3	7.4	9.9	8.6	4.4	.5	-3.9	-7.7
EXTREME MAXIMUM	8.3	11.7	16.1	22.8	30.6	33.9	40.0	40.6	32.2	26.1	17.8	8.9
EXTREME MINIMUM	-30.6	-30.0	-33.9	-6.1	-2.2	-.6	2.2	2.8	-5.0	-7.8	-33.3	-25.6
HEATING DEGREE DAYS(18C)	770	622	538	355	217	119	26	46	181	355	550	693

CLIMATOLOGICAL DATA FOR

KALISPELL

LAT: 48.22 LONG: 114.27 ELEV: 2959(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	20.3	25.0	33.7	43.7	52.4	58.4	66.0	64.0	54.5	44.4	32.0	24.7
DAILY MAXIMUM	28.0	34.1	43.2	55.2	65.0	71.4	82.1	80.5	68.9	55.8	39.1	31.2
DAILY MINIMUM	12.6	15.8	24.1	32.2	39.8	45.4	49.9	47.4	40.0	32.9	24.9	18.2
EXTREME MAXIMUM	47.0	53.0	61.0	73.0	87.0	93.0	104.0	105.0	90.0	79.0	64.0	48.0
EXTREME MINIMUM	-23.0	-22.0	-29.0	21.0	28.0	31.0	36.0	37.0	23.0	18.0	-28.0	-14.0
HEATING DEGREE DAYS(65F)	1386	1120	970	639	391	215	47	83	326	639	990	1249

CLIMATOLOGICAL DATA FOR

LEWISTOWN

LAT: 47.07 LONG: 109.42 ELEV: 1203(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-6.9	-5.3	-1.9	4.9	10.3	14.1	18.9	18.0	12.7	7.8	.1	-3.6
DAILY MAXIMUM	-.6	1.3	4.3	11.9	17.7	21.3	27.7	26.9	20.9	15.4	6.6	2.8
DAILY MINIMUM	-13.2	-11.9	-8.1	-2.2	2.9	6.8	10.1	9.1	4.5	.2	-6.4	-9.9
EXTREME MAXIMUM	18.9	17.8	23.3	31.7	33.3	37.2	37.8	39.4	35.6	31.7	25.0	23.3
EXTREME MINIMUM	-36.7	-41.1	-33.3	-27.2	-11.7	-2.2	.6	.0	-6.7	-23.3	-33.9	-35.6
HEATING DEGREE DAYS(18C)	776	635	638	422	253	125	36	46	178	322	546	677

CLIMATOLOGICAL DATA FOR

LEWISTOWN

LAT: 47.07 LONG: 109.42 ELEV: 3960(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	19.6	22.5	28.6	40.8	50.5	57.3	66.1	64.4	54.9	46.1	32.2	25.6
DAILY MAXIMUM	31.0	34.4	39.8	53.5	63.8	70.4	81.9	80.4	69.6	59.8	43.8	37.0
DAILY MINIMUM	8.2	10.5	17.4	28.0	37.2	44.2	50.2	48.3	40.1	32.3	20.5	14.2
EXTREME MAXIMUM	66.0	64.0	74.0	89.0	92.0	99.0	100.0	103.0	96.0	89.0	77.0	74.0
EXTREME MINIMUM	-34.0	-42.0	-28.0	-17.0	11.0	28.0	33.0	32.0	20.0	-10.0	-29.0	-32.0
HEATING DEGREE DAYS(65F)	1397	1143	1149	760	456	225	66	84	322	581	984	1219

CLIMATOLOGICAL DATA FOR

LIBBY

LAT: 48.40 LONG: 115.58 ELEV: 624(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-5.6	-2.2	2.4	7.7	12.4	15.8	19.7	18.5	13.9	7.9	.3	-2.9
DAILY MAXIMUM	-.7	3.8	9.7	16.8	22.3	25.7	32.1	30.8	24.5	15.2	4.6	.7
DAILY MINIMUM	-10.5	-8.3	-4.9	-1.4	2.6	5.8	7.3	6.1	3.3	.7	-4.1	-6.5
EXTREME MAXIMUM	13.3	17.2	23.9	31.7	38.9	38.9	42.2	42.8	38.9	31.7	19.4	13.9
EXTREME MINIMUM	-38.9	-38.3	-28.9	-20.6	-11.1	-4.4	-1.1	-2.2	-8.9	-21.7	-32.2	-31.1
HEATING DEGREE DAYS(18C)	716	550	510	331	189	88	26	35	140	340	547	655

CLIMATOLOGICAL DATA FOR

LIBBY

LAT: 48.40 LONG: 115.58 ELEV: 2053(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	22.0	28.0	36.4	45.8	54.4	60.4	67.5	65.3	57.0	46.3	32.5	26.8
DAILY MAXIMUM	30.8	38.9	49.5	62.2	72.1	78.2	89.7	87.5	76.1	59.4	40.2	33.3
DAILY MINIMUM	13.1	17.1	23.2	29.4	36.7	42.5	45.2	43.0	37.9	33.2	24.7	20.3
EXTREME MAXIMUM	56.0	63.0	75.0	89.0	102.0	102.0	108.0	109.0	102.0	89.0	67.0	57.0
EXTREME MINIMUM	-38.0	-37.0	-20.0	-5.0	12.0	24.0	30.0	28.0	16.0	-7.0	-26.0	-24.0
HEATING DEGREE DAYS(65F)	1290	991	919	596	341	159	48	64	252	613	985	1179

CLIMATOLOGICAL DATA FOR

LIVINGSTON

LAT: 45.65 LONG: 110.57 ELEV: 1364(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-4.1	-1.9	.8	6.4	11.3	15.1	20.1	19.1	14.1	9.2	1.9	-1.1
DAILY MAXIMUM	1.3	3.8	6.9	13.6	18.9	22.8	29.4	28.6	22.5	16.4	7.3	4.0
DAILY MINIMUM	-9.4	-7.7	-5.4	-.7	3.7	7.4	10.7	9.7	5.7	1.9	-3.6	-6.0
EXTREME MAXIMUM	15.0	19.4	22.2	30.6	33.9	40.6	38.9	38.3	36.7	29.4	22.8	20.0
EXTREME MINIMUM	-36.7	-42.8	-29.4	-23.3	-11.1	-2.2	1.7	.0	-6.7	-22.2	-32.8	-32.2
HEATING DEGREE DAYS(18C)	668	537	541	361	211	91	20	30	134	271	484	584

CLIMATOLOGICAL DATA FOR

LIVINGSTON

LAT: 45.65 LONG: 110.57 ELEV: 4490(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	24.7	28.5	33.4	43.6	52.4	59.2	68.2	66.4	57.4	48.6	35.4	30.1
DAILY MAXIMUM	34.3	38.8	44.5	56.4	66.0	73.0	85.0	83.4	72.5	61.6	45.2	39.2
DAILY MINIMUM	15.1	18.2	22.2	30.7	38.7	45.4	51.3	49.4	42.2	35.5	25.5	21.2
EXTREME MAXIMUM	59.0	67.0	72.0	87.0	93.0	105.0	102.0	101.0	98.0	85.0	73.0	68.0
EXTREME MINIMUM	-34.0	-45.0	-21.0	-10.0	12.0	28.0	35.0	32.0	20.0	-8.0	-27.0	-26.0
HEATING DEGREE DAYS(65F)	1204	968	974	650	380	165	36	55	242	488	872	1052

CLIMATOLOGICAL DATA FOR

MILESCITY

LAT: 46.42 LONG: 105.82 ELEV: 718(M)

TEMPERATURE AVERAGES BY MONTH						*** DEGREES CELSIUS ***					
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE											
-8.6	-6.5	-.6	7.6	14.1	18.7	24.1	22.6	16.1	9.4	.3	-4.9
DAILY MAXIMUM											
-2.6	-.1	5.7	14.8	21.4	25.8	32.3	30.8	24.0	16.9	6.4	.9
DAILY MINIMUM											
-14.7	-12.9	-7.0	.4	6.7	11.4	15.8	14.3	8.2	1.9	-5.7	-10.7
EXTREME MAXIMUM											
16.7	18.9	28.3	32.8	37.2	40.0	42.8	43.3	40.6	33.9	23.9	20.6
EXTREME MINIMUM											
-38.3	-38.3	-32.8	-13.9	-9.4	.0	5.0	1.7	-6.7	-12.8	-30.6	-35.0
HEATING DEGREE DAYS(18C)											
835	695	587	321	153	55	3	3	96	278	540	720

CLIMATOLOGICAL DATA FOR

MILESCITY

LAT: 46.42 LONG: 105.82 ELEV: 2364(FT)

TEMPERATURE AVERAGES BY MONTH						*** DEGREES FAHRENHEIT ***					
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE											
16.5	20.3	30.9	45.7	57.4	65.6	75.3	72.6	61.0	49.0	32.6	23.2
DAILY MAXIMUM											
27.4	31.8	42.3	58.6	70.6	78.5	90.2	87.5	75.2	62.4	43.5	33.6
DAILY MINIMUM											
5.6	8.7	19.4	32.8	44.1	52.6	60.4	57.7	46.7	35.5	21.7	12.8
EXTREME MAXIMUM											
62.0	66.0	83.0	91.0	99.0	104.0	109.0	110.0	105.0	93.0	75.0	69.0
EXTREME MINIMUM											
-37.0	-37.0	-27.0	7.0	15.0	32.0	41.0	35.0	20.0	9.0	-23.0	-31.0
HEATING DEGREE DAYS(65F)											
1504	1252	1057	579	276	99	6	6	174	502	972	1296

CLIMATOLOGICAL DATA FOR

MISSOULA

LAT: 46.87 LONG: 114.00 ELEV: 979(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-7.0	-3.5	1.5	7.1	12.0	15.7	20.2	18.9	13.2	7.2	-.1	-4.7
DAILY MAXIMUM	-1.9	2.1	7.6	14.4	19.9	23.8	30.2	28.8	21.9	14.4	4.9	-.2
DAILY MINIMUM	-12.2	-9.1	-4.6	-.3	4.1	7.5	10.2	9.1	4.5	-.2	-5.1	-9.2
EXTREME MAXIMUM	8.9	13.3	21.1	25.6	30.0	35.6	40.6	40.6	30.0	26.1	14.4	7.8
EXTREME MINIMUM	-25.6	-7.8	-22.2	-6.7	-5.6	-.6	2.2	.0	-4.4	-8.3	-16.7	-26.1
HEATING DEGREE DAYS(18C)	795	611	521	338	202	97	12	31	162	346	551	712

CLIMATOLOGICAL DATA FOR

MISSOULA

LAT: 46.87 LONG: 114.00 ELEV: 3223(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	19.4	25.7	34.7	44.7	53.6	60.2	68.4	66.1	55.8	44.9	31.9	23.6
DAILY MAXIMUM	28.6	35.7	45.6	57.9	67.8	74.8	86.3	83.8	71.4	58.0	40.9	31.6
DAILY MINIMUM	10.1	15.6	23.7	31.4	39.4	45.5	50.4	48.3	40.1	31.7	22.9	15.5
EXTREME MAXIMUM	48.0	56.0	70.0	78.0	86.0	96.0	105.0	105.0	86.0	79.0	58.0	46.0
EXTREME MINIMUM	-14.0	18.0	-8.0	20.0	22.0	31.0	36.0	32.0	24.0	17.0	2.0	-15.0
HEATING DEGREE DAYS(65F)	1414	1100	939	609	365	176	22	57	292	623	993	1283

CLIMATOLOGICAL DATA FOR

PLENTYWOOD

LAT: 48.78 LONG: 104.57 ELEV: 615(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-13.4	-10.2	-4.3	5.6	12.3	16.9	20.8	20.1	13.7	7.7	-2.2	-9.4
DAILY MAXIMUM	-7.3	-4.7	1.9	13.0	20.1	24.3	28.8	28.4	21.8	14.2	3.4	-3.2
DAILY MINIMUM	-20.4	-18.1	-10.9	-1.9	4.3	9.4	11.8	10.4	4.9	-1.3	-9.3	-15.4
EXTREME MAXIMUM	12.2	20.0	25.0	33.3	39.4	40.0	47.2	41.7	38.3	31.7	23.3	20.0
EXTREME MINIMUM	-46.1	-50.0	-38.9	-21.1	-11.7	-5.6	-1.1	-1.1	-12.8	-21.7	-35.0	-41.1
HEATING DEGREE DAYS(18C)	983	799	702	381	191	75	11	20	152	330	616	859

CLIMATOLOGICAL DATA FOR

PLENTYWOOD

LAT: 48.78 LONG: 104.57 ELEV: 2024(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	7.9	13.6	24.2	42.1	54.1	62.5	69.5	68.1	56.7	45.8	28.0	15.1
DAILY MAXIMUM	18.9	23.6	35.4	55.4	68.2	75.7	83.9	83.2	71.2	57.6	38.1	26.3
DAILY MINIMUM	-4.7	-.6	12.3	28.5	39.7	48.9	53.3	50.8	40.9	29.7	15.2	4.3
EXTREME MAXIMUM	54.0	68.0	77.0	92.0	103.0	104.0	117.0	107.0	101.0	89.0	74.0	68.0
EXTREME MINIMUM	-51.0	-58.0	-38.0	-6.0	11.0	22.0	30.0	30.0	9.0	-7.0	-31.0	-42.0
HEATING DEGREE DAYS(65F)	1770	1439	1265	687	344	135	21	37	275	595	1110	1547

CLIMATOLOGICAL DATA FOR

POLSON

LAT: 47.68 LONG: 114.17 ELEV: 896(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-3.9	-2.3	1.7	7.1	11.7	15.4	19.7	18.7	13.8	7.9	1.4	-1.3
DAILY MAXIMUM	-.6	1.8	6.7	13.2	18.4	22.3	27.9	26.8	20.7	13.3	5.3	1.9
DAILY MINIMUM	-7.4	-6.4	-3.2	1.1	4.9	8.6	11.3	10.6	6.8	2.6	-2.5	-4.4
EXTREME MAXIMUM	14.4	18.3	22.2	25.0	31.7	33.9	40.0	38.3	32.8	27.8	18.3	16.7
EXTREME MINIMUM	-34.4	-32.8	-23.3	-18.3	-8.3	-1.1	2.8	.6	-3.9	-17.2	-29.4	-25.6
HEATING DEGREE DAYS(18C)	667	553	530	346	216	100	31	31	146	338	518	608

CLIMATOLOGICAL DATA FOR

POLSON

LAT: 47.68 LONG: 114.17 ELEV: 2949(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	24.9	27.9	35.1	44.8	53.0	59.8	67.4	65.7	56.8	46.3	34.5	29.7
DAILY MAXIMUM	31.0	35.3	44.0	55.7	65.1	72.1	82.3	80.3	69.3	55.9	41.5	35.4
DAILY MINIMUM	18.7	20.4	26.2	33.9	40.8	47.4	52.4	51.1	44.2	36.6	27.5	24.0
EXTREME MAXIMUM	58.0	65.0	72.0	77.0	89.0	93.0	104.0	101.0	91.0	82.0	65.0	62.0
EXTREME MINIMUM	-30.0	-27.0	-10.0	-1.0	17.0	30.0	37.0	33.0	25.0	1.0	-21.0	-14.0
HEATING DEGREE DAYS(65F)	1201	996	954	623	389	180	57	57	264	609	934	1096

CLIMATOLOGICAL DATA FOR

RED LODGE

LAT: 45.18 LONG: 109.25 ELEV: 1686(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-5.3	-3.6	-1.9	4.2	9.3	13.2	17.9	17.2	11.8	7.3	.2	-3.1
DAILY MAXIMUM	.7	2.5	4.4	10.7	16.0	19.9	25.9	25.2	19.0	13.9	6.1	2.4
DAILY MINIMUM	-11.4	-9.7	-8.3	-2.3	2.7	6.3	9.9	9.3	4.6	.6	-5.6	-8.7
EXTREME MAXIMUM	21.1	17.2	21.1	25.6	29.4	33.3	36.7	35.0	32.2	28.3	22.8	17.2
EXTREME MINIMUM	-37.8	-31.7	-34.4	-23.3	-13.9	-3.9	-1.1	-2.2	-12.8	-13.9	-31.7	-35.0
HEATING DEGREE DAYS(18C)	717	594	610	429	262	142	38	54	185	329	534	652

CLIMATOLOGICAL DATA FOR

RED LODGE

LAT: 45.18 LONG: 109.25 ELEV: 5548(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	22.4	25.5	28.6	39.6	48.8	55.7	64.3	63.0	53.3	45.1	32.4	26.4
DAILY MAXIMUM	33.2	36.5	40.0	51.2	60.8	67.9	78.6	77.3	66.2	57.1	42.9	36.4
DAILY MINIMUM	11.5	14.5	17.1	27.9	36.8	43.4	49.9	48.7	40.3	33.1	21.9	16.3
EXTREME MAXIMUM	70.0	63.0	70.0	78.0	85.0	92.0	98.0	95.0	90.0	83.0	73.0	63.0
EXTREME MINIMUM	-36.0	-25.0	-30.0	-10.0	7.0	25.0	30.0	28.0	9.0	7.0	-25.0	-31.0
HEATING DEGREE DAYS(65F)	1291	1070	1098	773	473	256	70	98	333	593	962	1174

CLIMATOLOGICAL DATA FOR

SIDNEY

LAT: 47.70 LONG: 104.17 ELEV: 586(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-11.1	-7.7	-2.3	6.7	12.9	17.5	21.6	20.7	14.3	8.4	-.8	-7.1
DAILY MAXIMUM												
DAILY MINIMUM												
EXTREME MAXIMUM	DATA NOT AVAILABLE											
EXTREME MINIMUM												
HEATING DEGREE DAYS(18C)	911	727	638	350	175	65	9	18	140	306	575	788

CLIMATOLOGICAL DATA FOR

SIDNEY

LAT: 47.70 LONG: 104.17 ELEV: 1928(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	12.1	18.2	27.9	44.0	55.2	63.5	70.8	69.2	57.7	47.2	30.5	19.2
DAILY MAXIMUM												
DAILY MINIMUM												
EXTREME MAXIMUM	DATA NOT AVAILABLE											
EXTREME MINIMUM												
HEATING DEGREE DAYS(65F)	1640	1310	1150	630	315	118	17	33	253	552	1035	1420

CLIMATOLOGICAL DATA FOR

THOMPSON FALLS

LAT: 47.58 LONG: 115.33 ELEV: 748(M)

TEMPERATURE AVERAGES BY MONTH *** DEGREES CELSIUS ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	-3.1	.6	3.3	8.3	12.8	16.2	20.3	19.6	15.1	8.9	2.4	-1.1
DAILY MAXIMUM	1.2	5.7	9.9	16.3	21.5	24.8	31.0	30.2	24.6	16.2	6.8	2.4
DAILY MINIMUM	-7.3	-4.7	-3.3	.3	4.1	7.6	9.6	8.9	5.6	1.7	-2.1	-4.6
EXTREME MAXIMUM	13.3	17.8	25.6	32.2	36.1	37.8	42.8	41.7	41.1	31.7	18.3	14.4
EXTREME MINIMUM	-37.8	-34.4	-23.3	-8.3	-6.7	-1.1	1.7	.0	-4.4	-7.8	-25.0	-31.7
HEATING DEGREE DAYS(18C)	646	495	470	308	172	74	17	25	109	288	480	601

CLIMATOLOGICAL DATA FOR

THOMPSON FALLS

LAT: 47.58 LONG: 115.33 ELEV: 2463(FT)

TEMPERATURE AVERAGES BY MONTH *** DEGREES FAHRENHEIT ***

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE	26.5	33.0	38.0	46.9	55.0	61.2	68.5	67.2	59.2	48.1	36.3	30.1
DAILY MAXIMUM	34.1	42.3	49.9	61.3	70.7	76.6	87.8	86.3	76.2	61.2	44.3	36.4
DAILY MINIMUM	18.8	23.6	26.0	32.5	39.3	45.7	49.2	48.1	42.1	35.0	28.3	23.7
EXTREME MAXIMUM	56.0	64.0	78.0	90.0	97.0	100.0	109.0	107.0	106.0	89.0	65.0	58.0
EXTREME MINIMUM	-36.0	-30.0	-10.0	17.0	20.0	30.0	35.0	32.0	24.0	18.0	-13.0	-25.0
HEATING DEGREE DAYS(65F)	1164	891	847	556	311	134	32	46	197	519	864	1083

CLIMATOLOGICAL DATA FOR

WEST YELLOWSTONE

LAT: 44.92 LONG: 111.07 ELEV: 2026(M)

TEMPERATURE AVERAGES BY MONTH						*** DEGREES CELSIUS ***					
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE											
-10.6	-8.4	-5.3	1.1	6.7	10.8	15.3	14.1	8.9	3.2	-5.2	-9.9
DAILY MAXIMUM											
-4.3	-.4	3.4	8.9	15.2	19.8	26.6	25.2	19.1	11.8	1.6	-3.3
DAILY MINIMUM											
-16.9	-16.5	-14.1	-6.8	-1.8	1.8	4.1	2.9	-1.2	-5.4	-11.9	-16.6
EXTREME MAXIMUM											
7.8	13.3	16.1	22.2	28.3	32.8	35.0	35.6	32.8	26.1	17.8	12.2
EXTREME MINIMUM											
-51.1	-46.7	-41.7	-27.2	-17.8	-7.2	-6.7	-7.8	-11.7	-20.0	-37.8	-46.7
HEATING DEGREE DAYS(18C)											
910	756	744	526	353	217	83	127	272	464	702	884

CLIMATOLOGICAL DATA FOR

WEST YELLOWSTONE

LAT: 44.92 LONG: 111.07 ELEV: 6665(FT)

TEMPERATURE AVERAGES BY MONTH						*** DEGREES FAHRENHEIT ***					
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
DAILY AVERAGE											
12.9	16.8	22.4	33.9	44.1	51.5	59.6	57.3	48.1	37.8	22.7	14.1
DAILY MAXIMUM											
24.2	31.2	38.1	48.0	59.3	67.7	79.9	77.3	66.3	53.3	34.9	26.1
DAILY MINIMUM											
1.5	2.3	6.6	19.8	28.8	35.2	39.3	37.2	29.8	22.2	10.5	2.1
EXTREME MAXIMUM											
46.0	56.0	61.0	72.0	83.0	91.0	95.0	96.0	91.0	79.0	64.0	54.0
EXTREME MINIMUM											
-60.0	-52.0	-43.0	-17.0	.0	19.0	20.0	18.0	11.0	-4.0	-36.0	-52.0
HEATING DEGREE DAYS(65F)											
1638	1361	1340	947	636	392	151	230	491	836	1265	1592

APPENDIX I: REVIEW OF SOLAR DESIGN PROCEDURES

Introduction

An exhaustive critical review of the literature describing solar system design and economic analysis procedures is beyond the scope of this Data Manual. This review is presented to familiarize the user of this Manual with some of the better known procedures. Details of design procedures are described in many of the references listed in this Manual. These references are generally available from (a) local library resources such as Montana On-Line Reference Service; (b) government agencies (DOE, HUD, NBS, Government Printing Office); and (c) directly from the author of the reference.

Detailed simulation methods using large computers have been developed and used for research purposes and for the design of large and complex solar installations. These programs usually require hourly solar and weather data along with a detailed description of the solar system components and control system. The use of these precise methods is usually not economically justified for the design of small systems for a home or small commercial building.

Several simplified methods have been developed which use monthly average solar and weather data (such as the data given in this Manual). These methods have been developed under various government sponsored research projects and are available to the general public. Some well known methods are briefly discussed in this Manual to give the reader a general idea of the input requirements and the output produced by each method.

The inclusion of these design methods in this Manual does not constitute an endorsement of these procedures. The methods were selected for review because they are widely used and are generally available. The individual solar designer must select a design method appropriate to the requirements of his project.

Acknowledgement

Much of the material in this design section was taken from The California Data Manual. This manual is available from the California Energy

Commission, 1111 Howe Avenue, Sacramento, CA and contains much useful information. Thanks are due to the authors of the manual and to Dan Kazama for authorizing us to draw upon this work.

Cal-ERDA

This program is being developed by collaboration between Lawrence Berkeley Laboratory, Consultants Computation Bureau, Argonne National Laboratory, Los Alamos Scientific Laboratory, National Bureau of Standards, and Construction Engineering Research Laboratory, with support from the State of California and ERDA (hence the name). The program features a special language that facilitates the user's description of the building. Performance and cost evaluations can be made. The principal motivation for Cal-ERDA was energy conservation in buildings, but active solar systems (roof-mounted collectors) can be treated. The best source of information is the user's manual (Cal-ERDA Group, 1977).

University of Wisconsin F-chart Method

This method is based on a performance chart (the f-chart) that allows the user to determine the fraction, f, of the heating load provided by solar energy for a given collector area. The f-chart is applied after the user has specified the space heating and domestic hot-water load, certain parameters of the collecting system (for example, collector efficiency), the monthly total solar radiation, and the monthly mean temperature and heating degree days.

The f-chart method was developed from detailed considerations of solar heating systems for buildings by Klein, Beckman and Duffie (1976). The actual parameters of the chart were generated empirically from some 300 detailed simulations based on TRNSYS. There are at least four different approaches to the use of f-chart:

a. Original Papers

The basic method and its application to liquid systems is described by Klein, Beckman and Duffie (1976). An extension of the method to air systems is also given by the same authors (1977). The first paper includes a prescription for calculating the dollars saved annually by using a solar system

rather than a conventional system. The prescription also explains how to determine the collector area that maximizes the savings. The application of f-chart using these papers is not completely straightforward, and requires a good knowledge of solar energy fundamentals and a good grasp of mathematics. Most users will find the other approaches more convenient.

b. FCHART: The University of Wisconsin Interactive Solar Heating Design Program

FCHART is an interactive computer program version of the method as it is presented in the original papers. The program is accompanied by some descriptive material, but a knowledge of solar energy fundamentals is still helpful. The program handles all the calculations and provides pre-set (default) values for all the various input parameters. The user need only change those parameters that are different for the user's system. Solar and weather data are built into the program for 100 locations across the United States. The use of data contained in this Data Manual for specific Montana sites should improve the accuracy of this method. At the option of the user, FCHART will perform a life cycle cost analysis and determine the collector area that minimizes the costs.

c. Solar Heating of Buildings and Domestic Hot Water

This report contains an approach to f-chart developed by Beck and Field (1976) for the Naval Facilities Engineering Command. Methods are provided to estimate the yearly value of fuel saved, the "present worth" of 15 years of fuel savings, and the cost of solar energy systems. Worksheets and step-by-step instructions are given to guide the user in preparing the input to performance and cost analysis. The report presents descriptive and numerical information concerning many aspects of solar energy systems, including types of flat-plate collectors, collector heat losses, selective surfaces, storage methods, maintenance, temperature rise through collectors, and architectural considerations. Two complete examples are also given: one for a residence and the other for a dental dispensary. Though the report contains tables of solar radiation for 52 locations, using the solar and weather data in this Manual is recommended.

d. HUD Intermediate Minimum Property Standards for Solar Heating and Domestic Hot-Water Systems

This document, prepared by the National Bureau of Standards for HUD (NBS/HUD, 1976), gives a step-by-step approach to using f-chart. The space-heating step requires reference to another HUD report, but otherwise, the approach is largely self-contained. Though there is no cost analysis, the document contains a wealth of descriptive and numerical information. Topics include safety considerations, corrosion, material lifetimes, seismic and hail load, condensation in collectors, absorptive coatings, storage methods, ducts and pipes, heat transfer fluids, and sealing compounds. In addition, a complete example for a residence is given.

Solar data and mean temperatures (but not degree-days) are presented for 80 locations (2 in Montana). The use of the solar and weather data in this Manual is recommended.

Los Alamos Scientific Laboratory (LASL) Method

The basic idea of this method is similar to that of f-chart. An "x-factor" is defined that relates the fraction of the heating load supplied by solar energy to the collector area (Balcomb and Hedstrom, 1976). The parameters of the x-factor were determined empirically by a detailed computer simulation analysis of 25 U.S. and Canadian cities. The factor applies to air or liquid heating systems using flat-plate collectors.

In contrast to the f-chart, the x-factor has the parameters of a "standard" solar energy system built in. As a consequence, the LASL method is generally easier to apply than f-chart. On the other hand, the LASL method (with some exceptions, see below) cannot be used to examine the performance as a function of collector efficiency, tilt angle, and storage capacity per unit collector area. Another difference is that the LASL method only calculates the fraction of the annual load supplied by solar energy.

To use this method, it is necessary to specify the building's heating load in Btu's per degree-day, the monthly total radiation, and the monthly total degree-days. A step-by-step explanation of this method is described by Balcomb and Hedstrom (1976). The paper presents a quantity called "LC", which has been calculated from solar and weather data, along with the x-factor.

Once the user has specified the heating load in Btu's per degree-day, the tabulated values of LC can be used to calculate in a very simple way the required collector area for 25%, 50%, and 75% of the annual load to be supplied by solar. The knowledgeable solar-energy user should not have any difficulty using either LC or the x-factor as presented in the paper. A cost analysis is not included.

Martin Marietta Method (SOLCOST)

SOLCOST is a computer program developed by Martin Marietta (Denver) for ERDA. Connolly et al. (1976) have given a technical description of the method, but its application requires the computer program and the user's manual (Martin Marietta, 1977). SOLCOST has received some, but not extensive, verification.

SOLCOST differs from f-chart and the LASL method in that it performs a detailed simulation for an "average day" for each month. According to Connolly et al. (1976), "this approach provides an accurate solution while keeping computer costs to a reasonable value". SOLCOST is more versatile than the other methods. It is designed to handle hot-water systems, absorption cycle air conditioners, solar-assisted heat pumps, and some passive features, as well as air and liquid space-heating systems. A variety of methods can be used to specify the load, ranging from monthly fuel bills to transient simulations. Collectors may be evacuated tubes, or one- or two-axis concentrators, in addition to flat plates.

The weather data required are minimum and maximum temperatures, heating degree days and (for cooling only) minimum and maximum relative humidity. The solar data are percent possible sunshine (PP) and "clearness number". The program uses a recipe to compute the solar radiation. The weather and solar data are built into the program for 124 cities (2 in Montana). Data in this Montana Solar Data Manual can be used to improve these estimates.

The program will perform a life-cycle cost analysis relative to a reference system. At the user's option, the program will compute the collector area that minimizes this cost.

Users with a good knowledge of solar energy fundamentals should not have any particular difficulty applying SOLCOST. The user's manual provides

standard forms to help structure the input to the program. The forms must then be converted to punched cards by someone familiar with computer input formats. Most of the input parameters have pre-set (default) values and only those that are different for the user's applications need be changed.

The solar designer can send his system description to commercial sources who have implemented SOLCOST on their computer. For a fee of less than $50 they will run his system and send the SOLCOST output to him.

Other Design Resources

Design routines which can be implemented on low cost hand calculators have been developed. Some programs are available in the literature and may be copied. Software for passive and active solar design using programmable hand calculators are available from several commerical sources. (Look for advertisements in monthly periodicals such as Solar Engineering, Solar Age, Solar Heating & Cooling, or various "Guides" to solar equipment.)

Manufacturers of solar equipment usually provide some type of design support to help the user select properly sized components. Lists of manufacturers are available through government sources, trade journals and solar energy books available at many local bookstores.

The design services of local engineers, architects and heating contractors may be used. Names and addresses can be obtained through the appropriate professional organizations, trade organizations or the Yellow Pages of the phone book.

Conclusion

The solar data in this Manual should be utilized in any of the preceding design procedures. At this time our solar data covers only three to four years and should not be considered "typical". If you enlist the design services of consultants and manufacturers (especially those outside Montana) you should make them aware of the information in the Montana Solar Data Manual.

There has been a rapid growth in all areas of solar utilization in the past few years. In the late 1960's there were only about a dozen solar heated buildings in the United States; now there are thousands of solar homes

completed or under construction. In Montana there is probably at least one solar home within 50 miles of your home. A number of these homes are "demonstration projects" funded by the Alternative Renewable Energy Sources Program of the Montana DNR&C and are available to the public for viewing. A person who is considering investing in a solar system should visit these homes.

The novice solar designer has an increasing resource base against which he can measure and improve his ideas. The novice designer would do well to keep in mind the adage "Those who neglect to study history are fated to repeat it".

Summaries of FCHART, LASL and SOLCOST requirements are shown on the following pages.

UNIVERSITY OF WISCONSIN METHOD (F-CHART)

Computation level:	Hand calculator with trig functions.	(a)
	Interactive computer program.	(b)
	Hand calculator.	(c,d)
Units:	Metric (a); Engineering (c,d); Either system (b).	
Solar system types:	Liquid flat plate collector, heat exchanger to storage tank, w/wo domestic hot water.	(a,b,c,d)
or:	Air flat plate collector, pebble bed storage, w/wo domestic hot water.	(a,b,c,d)
Solar data needed:	Monthly total radiation on tilted surface.	(a,c,d)
or:	Monthly total radiation on horizontal surface and tilt calculation.	(a,b,c,d)
Tilt calculation:	Equation for any tilt angle, south orientation.	(a)
	Built-in for any tilt angle, south orientation.	(b)
	Graph for latitude $+10^{o}$, south orientation.	(c)
	Tables for latitude, latitude $\pm 15^{o}$, vertical, south orientation.	(d)
Weather data needed:	Monthly average ambient temperature and degree days.	(a,b,c,d)
System parameters:	Slope and intercept of collector efficiency curve.	(a,b,c,d)
	Effectiveness of collector-tank heat exchanger.	(a,b,c,d)*
	Various heat capacity flow rates.	(a,b,c,d)*
	Storage tank volume per unit collector area.	(a,b,c,d)
Space heating input:	Building load in energy units per month.	(a,b,c,d)
or:	Constant characterizing the load in units of energy per degree-day.	(a,b,c,d)
Hot water input:	Domestic hot water load in energy units.	(a,b,c,d)
or:	Constants characterizing the demand, water main temperature, minimum acceptable temperature.	(a,b,c,d)
Cost analysis:	"Annual Dollar Savings" based on $\$/m^2$ of collector (installed), fixed costs, \$/unit capacity storage, annual charge on capital investment, auxiliary fuel costs.	(a)
	"Life-cycle" based on collector area dependent costs; fixed costs; down payment, interest, term of mortgage, discount rate; insurance and maintenance; present cost of fuel and rate of increase.	(b)
	"Dollar Value of Fuel Saved" based on cost of fuel and furnace efficiency.	(c)
	"Present Worth of 15 Years of Fuel Saved" based on inflation rate and discount rate (estimates provided).	(c)
	"Cost of Solar System" based on $\$/ft^2$ of collector, storage, auxiliary heating installed, miscellaneous, and contractor fees.	(c)

(a) Original papers; Klein, Beckman and Duffie (1976 and 1977).
(b) Interactive computer program; FCHART (1976).
(c) Solar Heating of Buildings and Domestic Hot Water; Beck and Field (1976).
(d) Intermediate Minimum Property Standards for Solar Heating ....; NBS/HUD (1976).
* These parameters can often be ignored. They are used in a correction factor that is 1.0 for systems without heat exchangers and very close to 1.0 for efficient systems with exchangers.

LOS ALAMOS SCIENTIFIC LABORATORY METHOD (LASL)

Computation level:	Hand calculator for LC (Load-Collector ratio) approach.	(a,b)
	Hand calculator with trig functions for X-factor.	(a,b)
Units:	Engineering	(a,b)
Solar system types:	Liquid flat plate collector, heat exchanger to storage tank, w/wo domestic hot water, forced air heat.	(a,b)
or:	Air flat plate collector, rock bed storage, w/wo domestic hot water, forced air heat.	(a,b)
Solar data needed:	Monthly total radiation on tilted surface.	(a,b)
	Monthly total radiation on horizontal surface and tilt calculation.	(a,b)
Tilt calculation:	Equation for latitude $+10^{o}$, south orientation.	(a,b)
Weather data needed:	Monthly degree days.	(a,b)
System parameters:	For basic method (any location); none.	(a,b)
	For six special cities with hourly solar data graphs show liquid system performance dependence on: type of collector (single vs. double glazing, selective surface); collector orientation, tilt, cover glass transmissivity, surface absorptance and emittance, coolant flow rate, heat transfer coefficient, back insulation, and heat capacity; distribution pipe insulation, heat exchanger effectiveness; thermal storage heat capacity and heat losses; design water temperature.	(b)
	For air systems, graphs show dependence on: collector heat transfer effectiveness; air flow rate, thermal storage capacity, and rock bed temperature distribution.	(b)
Space heating input:	Building load in Btu per degree-day.	(a,b)
Hot water input:	Estimated load.	(a,b)
Cost analysis:	"Cost of Solar Heat" in dollars per million Btu's based on: system installation cost/ft^2; annual capital fixed charge rate; and annual operating, maintenance and repair cost.	(b)
	"Break-Even Point" in dollars per ft^2 of collector based on: alternate energy cost and forecasted annual increase; and useful solar energy delivered per ft^2 of collector.	

(a) Original paper; Balcomb and Hedstrom (1976).
(b) ERDA's Pacific Regional Solar Heating Handbook; ERDA-SAN/LASL (1976).

MARTIN MARIETTA METHOD (SOLCOST)

Computation level:	Batch process computer program.
Units:	Engineering.
Solar system types:	Space and domestic hot-water heating systems with air or liquid collectors.
or:	Absorption cycle air conditioning.
or:	Solar assisted heat pumps.
or:	Systems with some passive features.
Collector types:	Flat plate, evacuated tube, one- or two-axis trackers.
Solar data needed:	Percent possible sunshine and clearness number (default value of clearness number supplied by program from contour map).
Tilt calculation:	Built in for any tilt and orientation.
Weather data needed:	Minimum/maximum temperature. Heating degree-days. Min/max relative humidity (solar cooling only).
System parameters:	Collector efficiency parameters from efficiency curve. Storage capacity per collector area (liquid systems only). Fuel type, efficiency of auxiliary heat source. COP for solar assisted heat pump (heat pump application only). Various flags to specify collector type.
Heat/cool input:	Building Load in energy units.
or:	Monthly fuel bills and description of existing HVAC system (retrofit only).
or:	Building dimensions for buildings meeting ASHRAE standard 90-75.
or:	UA (U-factor) in Btu/hr-^{o}F.
or:	Detailed specification of building for steady-state calculation.
or:	Detailed specification for transient calculation. (Recommended by the authors for buildings with passive features.)
Hot water input:	Hot water load in energy units.
Cost analysis:	"Life cycle" relative to a reference system. The following types of information are used: Reference System: initial installed cost and maintenance. Solar System: fixed cost, installed cost per unit collector area, liquid storage installed cost per gallon, maintenance cost. Finance/Tax Data: scenario indicator (residence, business, non-profit), loan interest rate, loan term, loan down payment, insurance, property tax rate, income tax rate, various depreciation factors for businesses. Fuel Costs: dollars per unit; escalation rate; heat content per unit for any of natural gas, electricity, fuel oil, LPG, coal.

Note: All entries referenced to SOLCOST User's Guide; Martin Marietta (1977).

APPENDIX II : ECONOMIC EVALUATION OF SOLAR SYSTEMS

Introduction

Solar radiation is a "free" source of energy but to capture this free energy the user must invest a significant amount of money in solar collection equipment. (A solar system for a residence will cost approximately $7,000 to $15,000.) Once this initial investment is made, yearly energy costs consist of maintenance, taxes, interest and auxiliary energy used during exceptionally cold and cloudy periods. These costs must be compared to the alternative of a conventional heating system and increasing yearly payments for fossil fuels.

Many economic analyses of solar systems are available in government publications and the solar energy literature. Some of the solar design methods reviewed in this Manual include economic analyses as part of the package. For example, one prepared program available for hand programmable calculators (TI-59 or HP-67) includes in its economic analyses: the mortgage period; the mortgage interest rate; the general inflation rate; the insurance rate; the effective federal-state income tax rate; the property tax rate; tax credits; the down payment; the salvage value; the investment tax credit; the period of analysis; the market discount rate; the operating, maintenance, and fuel costs and their rates of increase; the system base cost and the collector costs. Depreciation can be calculated using either declining balance, straight line or sum of year's digits.

All economic analyses depend on predictions of future inflation rates, fossil fuel costs and solar equipment costs. These predictions have a high degree of uncertainty. Further, small changes in the assumed values of these quantities can make dramatic changes in the economic conclusions. There is some consensus of expert opinion on the following important points: (a) Energy cost will increase about 1% per year above the inflation rate, and (b) Solar equipment costs will probably increase with the inflation rate with only minor possible reductions with mass production.

A Simple Economic Model

A simple method of economic analysis is presented below for the solar designer who wants to do it himself. This method was developed under a Department of Energy grant by Charles D. Kolstad of Los Alamos Scientific Laboratory.

The analysis utilizes "real dollars" to simplify the calculations. For example: if the inflation rate is 8% and the cost of a solar loan at the bank is 11% the "real interest" is 11% - 8%, or 3%. If you are paying for the solar system with money from your savings account which pays 5½% then the "real interest" for your money is 3½%. Similarly, if fuel costs escalate at 9% overall rate with an 8% inflation rate, the "real" escalation rate of fuel costs is 1% per year. A form for effecting the economic analysis is given in Table 1.

Sample Economic Analysis

Assume we wish to install a solar system on a new house. The system will use 15 m^2 of collector and a performance analysis predicts that the system will supply 68% of the annual energy requirement. A heat load analysis predicts an annual requirement of 120 x 10^9 Joules (120 GJ). The system will cost $10,000. The alternative is to use electric resistance heat. The average cost of power at the site is $0.025/kW-hr (or $6.94/GJ).

The federal tax credit will be $2,200 on this system and the Montana tax credit will be $275. The total tax credit is thus $2475. The bank will loan us the money for the system at 12% for 20 years and the inflation rate is estimated at 8%. This interest is a deduction on our federal taxes, which for our tax bracket reduces the effective interest rate by 1%. These values are entered into the form in Table 2. The sample calculations show that this solar system costing $560/year would be economically competitive with electric heat costing $566/year. Note that if natural gas is available, this solar system, using the listed assumptions, would not be economically competitive over the 20 year period.

It is suggested that the solar designer go through this economic analysis for several combinations of assumptions of fuel escalation rate and inflation rate.

System cost		A
Tax credit		B
Net system cost		C = A − B
Real interest rate		D
Real fuel escalation rate		E
Tax deduction for interest		F
Net real interest rate		G = D − E − F
Annualized cost		H
Annual maintenance		I
Annual solar cost		J = H + I

Annual heat load		K
Annual solar heat		L
Current energy cost		M
Net energy cost		N
Annual cost of alternative heat		O = K x N
Annual value of solar heat		P = L x N

(Cost) $/kWh x 278 = (Cost) $/GJ

(Cost) $/$10^6$ BTU * .95 = (Cost) $/GJ

1 x 10^6 BTU = 1.05 GJ

Notes:

A. Total installed cost of solar system

B. Federal and state tax deductions (ask tax consultant)

D. Annual interest minus inflation (ask bank for information)

E. Consult expert (about 1%)

F. Depends on your tax bracket (ask tax consultant)

H. Use Tables for Net Cost and Net real interest

I. Usually 1% to 5% of initial cost

K. Use calculated heat load or past fuel bills

L. From solar performance calculations

M. Ask utility company

N. M x 1 for electric heat; M x 1.6 for gas or oil

O. Assuming no solar system is installed

Table 1. ECONOMIC ANALYSIS

	$ Annual payment/$1000 loan							
Yrs.	1%	2%	3%	5%	7%	8%	9%	10%
5	206	212	218	231	244	250	257	264
10	106	111	117	129	142	149	156	163
20	55	61	67	80	94	102	110	117
25	45	51	57	71	86	94	102	110
30	39	45	51	65	81	89	97	106
40	30	37	43	58	75	84	93	102
50	26	32	39	55	72	82	91	101

System cost	$10,000	A
Tax credit	$2,475	B Fed+state
Net system cost	$7,525	C = A − B
Real interest rate	4%	D 12%−8%
Real fuel escalation rate	1%	E assumed
Tax deduction for interest	1%	F approx.
Net real interest rate	2%	G = D − E − F
Annualized cost	$460	H $.061 x 7,525
Annual maintenance	100	I .01 x $10,000
Annual solar cost	$560.00	J = H + I

Notes:

A. Total installed cost of solar system

B. Federal and state tax deductions (ask tax consultant)

D. Annual interest minus inflation 8% inflation (ask bank for information) 20 year loan

E. Consult expert (about 1%) assume 1%

F. Depends on your tax bracket about 1% (ask tax consultant)

H. Use Tables for Net Cost and Net real interest →

I. Usually (1%) to 5% of initial cost

K. Use calculated heat load or past fuel bills

L. From solar performance calculations 68% solar

M. Ask utility company $.025/kWh x 278 = $6.94/GJ

N. (M x 1) for electric heat; M x 1.6 for gas or oil

O. Assuming no solar system is installed

Annual heat load	120 GJ	K
Annual solar heat	81.6 GJ	L .68 x 120
Current energy cost	$6.94/GJ	M
Net energy cost	$6.94/GJ	N M x 1 electric heat
Annual cost of alternative heat	$832.80	O = K x N 120 x $6.94
Annual value of solar heat	$566.00	P = L x N 81.6 x $6.94

(Cost) $/kWh x 278 = (Cost) $/GJ

(Cost) $/$10^6$ BTU * .95 = (Cost) $/GJ

1 x 10^6 BTU = 1.05 GJ

Table 2. SAMPLE ECONOMIC ANALYSIS

$ Annual payment/$1000 loan								
Yrs.	1%	(2%)	3%	5%	7%	8%	9%	10%
5	206	212	218	231	244	250	257	264
10	106	111	117	129	142	149	156	163
(20)	55	(61)	67	80	94	102	110	117
25	45	51	57	71	86	94	102	110
30	39	45	51	65	81	89	97	106
40	30	37	43	58	75	84	93	102
50	26	32	39	55	72	82	91	101

APPENDIX III: ACCURACY OF SIMM SOLAR RADIATION MEASUREMENTS

Instrumentation

The solar radiation measurements were made using a silicon cell-based transducer fabricated by Fowlkes Engineering and a Rustrak Model 288, 0-1 ma, strip chart recorder. The silicon cell is 2 cm square and is attached flush to the center of a flat aluminum heat sink approximately 8 cm square. An aluminum reflective mask, 8 cm square and 0.5 mm thick, having a 1.9 cm square hole is centered over the silicon cell. A piece of double strength window glass, 8 cm square and 3 mm thick, covers the assembly. The assembly is sealed along the perimeter with clear silicone rubber caulking to prevent moisture from entering. The purpose of the reflector and the heat sink is to stabilize the temperature of the silicon cell.

The output of the silicon cell is shunted with a wire wound resistor having a resistance of less than 1 Ω . The voltage drop across this resistor at normal incidence on a clear day is about 80 mv. The recorder has an input impedance of about 100 Ω and is consequently deflected to about 80% of full scale at solar noon on a clear day. To reduce the effect of lead resistance, two- conductor, #18 solid copper wire is used to connect the transducer to the recorder.

Initial Calibration

Each transducer-lead wire-recorder assembly is individually calibrated by comparison to a Kipp or Eppley pyranometer. The reference pyranometer and silicon cell transducer are mounted in the same plane. The plane of the transducers is adjusted approximately normal to the solar radiation on a clear day near solar noon. Several simultaneous readings of both instruments are averaged to establish the initial calibration factor. The reference pyranometer was manufactured by Kipp and was recalibrated at the NOAA Laboratories in Boulder, Colorado by Dr. Ed Flowers. One of the SIMM transducers was also calibrated at the NOAA Laboratories in 1978. Periodic comparisons with several other Eppley and Li-Cor pyranometers have shown agreement with the reference to within $\pm$ 5% or better.

Silicon Cell Characteristics

Silicon cell characteristics relating to solar flux measurement are well documented in the literature (see References) and several commercial silicon cell instruments are available. Briefly, the silicon cell characteristics causing departures from pyranometer readings are due to spectral response, temperature changes and cosine response. The spectral response will cause the silicon cell to read measurably higher on cloudy days and within 2 hours of sunrise or sunset. The instruments used in this program, for example, will be 0.015 kW/m^2 high under conditions of 80% beam attenuation due to clouds. The amplitude error in this condition is $\pm$ 6%. The effect of this spectral error on the monthly average, daily total energy density (the values tabulated in this Manual) is typically reduced to less than 3%. This reduced error is due to the relatively low energy density on cloudy days. Similarly, amplitude errors near sunrise and sunset have a small effect on daily total energy density: less than 2% on a clear day.

Temperature coefficients of about +0.001/°C are given in the literature for silicon cells used for flux measurements. All instruments used in this project were calibrated during the month of January. Summer operating temperatures would be about 35° C higher which, based on + 0.001/°C, would produce 3.5% higher amplitudes for a given radiant flux. It might be noted that some commercial pyranometers have a temperature sensitivity of about -0.001/°C.

Transducer Errors

The SIMM silicon cell transducer is covered by a glass plate potted in silicone sealant. Tilt calibration tests have shown that the output of the SIMM transducer falls off at large angles of incidence. This is due primarily to the glass cover plate and is normally termed cosine error.

The measured cosine response of the SIMM transducer was input into a computer simulation model to predict the effect of this error on the daily total insolation throughout the year. The following table shows the results of this computer model. Experimental data presented later in this report indicates that the summer errors are less than those predicted by the model.

CALCULATED EFFECT OF COSINE ERROR, %

MONTH	CLEAR DAY	AVERAGE DAY
DEC	-2	-2
JAN NOV	-3	-2
FEB OCT	-4	-3
MAR SEP	-4	-3
APR AUG	-6	-4
MAY JUL	-8	-5
JUN	-8	-5

Orientation Errors

The nominal plane of measurement is 60° up from horizontal and south facing. No thorough measurements are available to establish typical accuracy of the plane of the transducers at this time. The attachment bracket was fabricated to ± 1° and many of the transducers used buildings oriented true south for mounting. A compass was used in some cases, corrected for the local magnetic deviation, to establish the azimuth.

The error due to misalignment varies as cos $(\theta + \delta)$ where δ is the misalignment and θ is the angle between the radiation on a normal-to-the-transducer plane. At solar noon during the heating season this error would be a maximum of around 0.3% per degree of misalignment. This error will be assumed negligible until further data and analyses are available.

Recorder Errors

The published absolute accuracy of the strip chart recorders is 3%. This error is reduced significantly since the recorders are directly calibrated in conjunction with the transducers. The readability of the recorder during calibration, using a magnifier, is estimated at better than ± 1%.

The electrical circuit used is sensitive to changes in lead resistance. This factor has probably been the primary source of error in this measurement program. At a few stations extra lead wire was installed after calibration. Even more important have been resistance variations

due to improperly soldered lead wire connections. The gradually increasing contact resistance leads to a gradual reduction in sensitivity of the instrument. In a few cases this problem has been responsible for temporary errors of 10 and 20%.

Data Reduction Errors

Strip chart data is processed by tracing the curves on a digitizer platen connected to a microcomputer. The resolution of the platen is 0.1 mm and each curve is represented by 200 to 400 coordinates. The reading error due to resolution is, thus, less than 1%. The primary source of data reduction error is the repeatability of the curve tracing itself. On clear days, where the curve is a well defined line, the reproducibility averages 1%. On cloudy days the reproducibility can reach 5 to 20%. This is due to the fast response of the silicon cell which produces a very rough, jagged curve on some cloudy days (see cover of Manual for examples of curves).

During the last year, reproducibility tests have been run on over 800 data days (4% of our total data base). The reproducibility of the monthly average, daily total energy density averages better than $\pm$ 2%. These monthly values often reproduce within 1% due to the compensation of positive and negative errors when averaged.

Data Correction Procedures for SOLMET

The Department of Energy has sponsored programs to compile and review historical solar insolation data for the purpose of providing a data base for the design of solar energy conversion devices. Expert review of the data pointed to a myriad of errors due to instrumentation, data collection and presentation. Programs were subsequently initiated to "rehabilitate" this data base.

A key part of the rehabiliatation consisted of reviewing approximately 190,000 solar radiation charts and extracting the radiation intensity at solar noon on clear days. A parallel effort consisted of computing predicted clear-day noon radiation using a variety of theoretical models and atmospheric data. The comparison of the theoretical and experimental clear-day data identified unreliable solar data (some

data being 20% in error). The comparison further helped provide correction factors which were applied to the experimental data to produce the "rehabilitated" solar data base. The rehabilitated data is believed to be accurate to within ± 5%. This data is now available in the form of tables and computer-readable tapes for 26 locations in the United States; Great Falls is among the rehabilitated stations.

Estimates of the solar radiation at an additional 222 locations were derived from atmospheric data and are included in the SOLMET data base. Eight of these locations are in Montana. The accuracy of this calculation method for Great Falls is ± 13% for daily values and ± 4% for monthly averages.

Data Correction Procedures for SIMM

The clear-day comparison procedure described above was also utilized in processing the data presented in this Manual. This comparison significantly reduces the probability of large errors in the solar radiation due to faulty instrumentation. We were fortunate to have the guidance of expert consultants in this crucial area.

Douglas V. Hoyt of NOAA in Boulder, Colorado was involved with the rehabilitation of the SOLMET data base using his theoretical model for the calculation of solar noon atmospheric transmission. He was able to provide us with theoretical clear-day values on a 60° tilted surface in Montana using his comprehensive atmospheric model. He also advised us as to the effect of altitude on our clear-day values and provided general guidance in assessing the accuracy of the data.

John Yellott has provided useful advice on the behavior of silicon cell-based instruments for measuring solar radiation since the inception of this measurement program. Prof. Yellott holds a patent on the temperature-compensated silicon cell radiometer. He also advised us concerning the use of the ASHRAE clear-day model for checking instruments for calibration drift.

Our Theoretical Clear-Day Model

For this report we used a theoretical clear-day model based on one

given in the ASHRAE Handbook of Fundamentals. Our model included an adjustment for altitude consisting of a clearness factor allowing + 1% per 1000 feet in elevation. The effect of ground reflection was included by assuming a reflectance of 0.5 (snow) for Nov. 15 to March 1 and a reflectance of 0.2 during the remainder of the year.

The results from Doug Hoyt's clear-day model and our modified ASHRAE clear-day models are shown in Figure 1(a) for Great Falls along with the experimental data. The two theoretical curves are within ± 2.5%. Most of the experimental data is also contained in this ± 2.5% error band.

Note that some experimental clear-day values in winter are as much as 5% above the theoretical values. Several stations showed a similar relative increase in clear-day values during winter. At this time we don't know if the experimental data or the theoretical model is responsible for this departure. The Great Falls experimental data was not corrected due to the close agreement with the theoretical values.

Figure 1(b) shows the clear-day comparison for Glendive. The discrepancy between the theoretical and experimental values suggested a uniform offset in the calibration factor of 4.5%. The data presented in the tables is the raw data multiplied by a factor of 1.045. The dashed curve in Figure 1(b) shows how this offset factor produces an improved fit between the experimental data and the clear-day model.

National Solar Data Network Comparison

The Billings Shipping solar system in Billings, Montana was instrumented three years ago for performance monitoring as part of The National Solar Data Network (NSDN). Global insolation is measured here by an Eppley PSP pyranometer tilted at 50°. Daily totals and maximums are reported each month in "Environmental Data for Sites in the National Solar Data Network", DOE National Solar Data Program, Solar 10010-80.

During 1980 there were 337 days of simultaneous data from both the NSDN, Eppley PSP and the SIMM transducer at Billings High School. The NSDN 50° tilt data was converted to a 60° tilt using the ratio of ASHRAE clear day totals. This simplified method would tend to over-correct the NSDN data by a few percent in the summer. Since the correc-

tion itself averages only about ± 3%, the error introduced is not large.

A scatter plot of daily total insolation for SIMM vs. NSDN for 1980 is shown in Figure 2. For 337 common data days, the linear correlation coefficient was 0.990. There are about a dozen points that are scattered. These discrepancies probably occurred on days when snow or frost covered one transducer part of that day. Neither instrument is regularly cleaned or cleared of snow. The remaining scatter is primarily due to differences in spectral response, calibration error, cosine response and temperature coefficient (annual temperature extremes span over 70° C).

The daily totals for the month of November, 1980 are shown in Table 1. The daily average insolation for November for the SIMM instrument is 3.07% less than the NSDN instrument. This difference closely corresponds to the -3% error predicted for this month due to the low cosine response of the SIMM transducer.

The average daily totals for each instrument are shown for each month in 1980 in Table 2. The SIMM instrument is normally lower by a few percent, which is probably due to cosine error. (The December average is faulted because the SIMM instrument was not recording data during a week with several clear days.)

Bozeman Side By Side Comparisons

Side by side comparisons were run for eight months during the winter of 1980 and spring of 1981 to compare (a) a Kipp pyranometer, (b) a Li-Cor 200S silicon cell radiometer, and (c) the SIMM silicon cell radiometer. All transducers were mounted at 0° azimuth and 60° tilt and connected to a microcomputer based data acquisition system (DAS). The DAS had a resolution of 12 bits, an accuracy of better than ± 0.5%; each transducer and the ambient air temperature were sampled once each second. These readings were averaged over 10 minute intervals and the average data stored on magnetic tape. This data base consists of 15×10^6 side by side readings of each transducer.

Table 3 shows a typical portion of this data base condensed into daily total insolation. The Kipp pyranometer was recalibrated at the NOAA facility in 1979 and this calibration factor was used. The factory calibration supplied for the Li-Cor was used and the SIMM transducer was calibrated to the Kipp on a clear day near solar noon

according to our standard procedure. No correction was made for ambient temperature, which varied between -18° C and +17° C during this period. The monthly totals of the Kipp and the Li-Cor agree to within ± 1% while the SIMM transducer is 3% below the Kipp. This lower reading agrees with the predictions of the cosine error model discussed previously.

The instantaneous readings of the three transducers during mid-day in clear weather were always within a ± 5% band and often were within ± 1%. The Kipp and the Li-Cor were typically within ± 0.01 $kW-m^{-2}$ for the entire day, while the SIMM transducer's output would typically be 0.05 $kW-m^{-2}$ low in early morning and late afternoon (the cosine error).

Summary

The expected error in the monthly average data for any station has been summarized by assigning to each station a classification ranging from I to III. This error classification was based primarily on comparisons of theoretical and experimental clear-day values, before and after adjustment. Table 4 lists these comparisons.

Additional information from our instrument records and fault code files was also used to refine the classification. For example, Helena is Class I even though the adjusted error is 4.6, the highest of any Class I station. This scatter is due to a characteristic haze in Helena which effects the "clear-day" values. Lewistown was rated Class III even though the adjusted clear-day error was only 2.3% (less than many Class I stations). Lewistown's rating was reduced due to persistent problems with unreliable connections and slipping chart paper which reduced the overall integrity of the data.

Based on our current clear-day model, we suggest the following overall error bands for monthly average data:

Class I stations	± 3%
Class II stations	± 5%
Class III stations	± 8%

All calculations to date indicate that if there is a significant discrepancy, the solar data in this Manual will be conservative; i.e. less than the true value. This error margin is due to the cosine response of the instruments and the clear day calibration method.

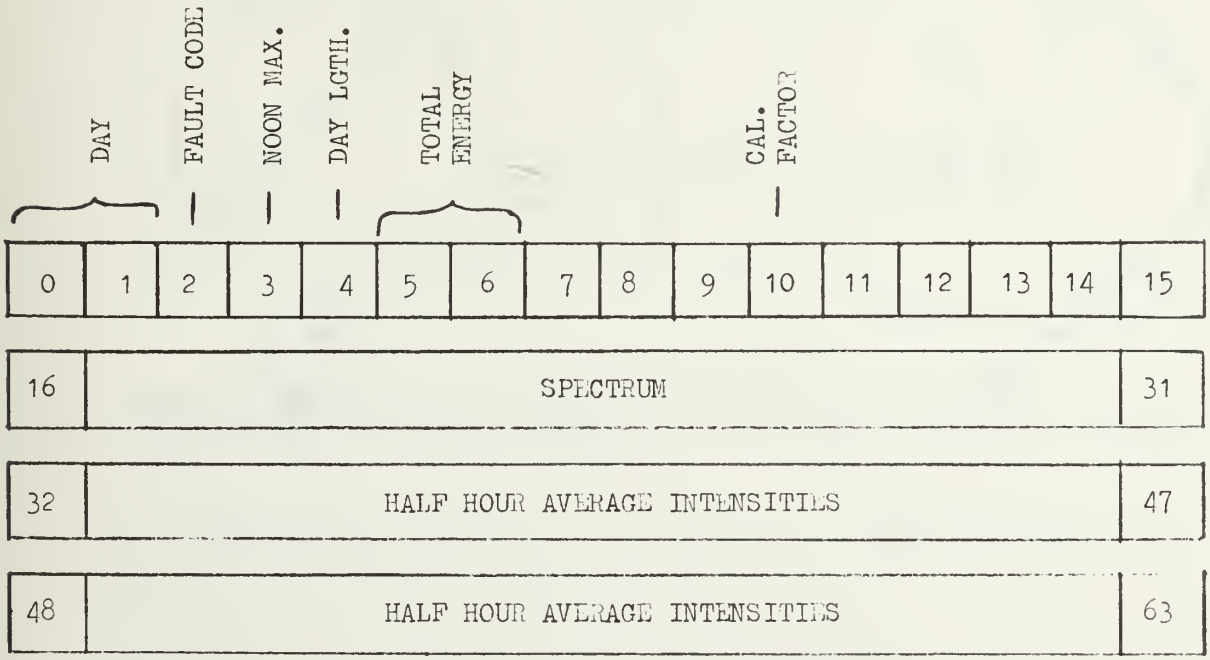
(A solar system designed using radiation data that is 10% low will produce about 5% more heat than expected.) The errors in the data in this Manual are probably less than the error band of most solar system design methods.

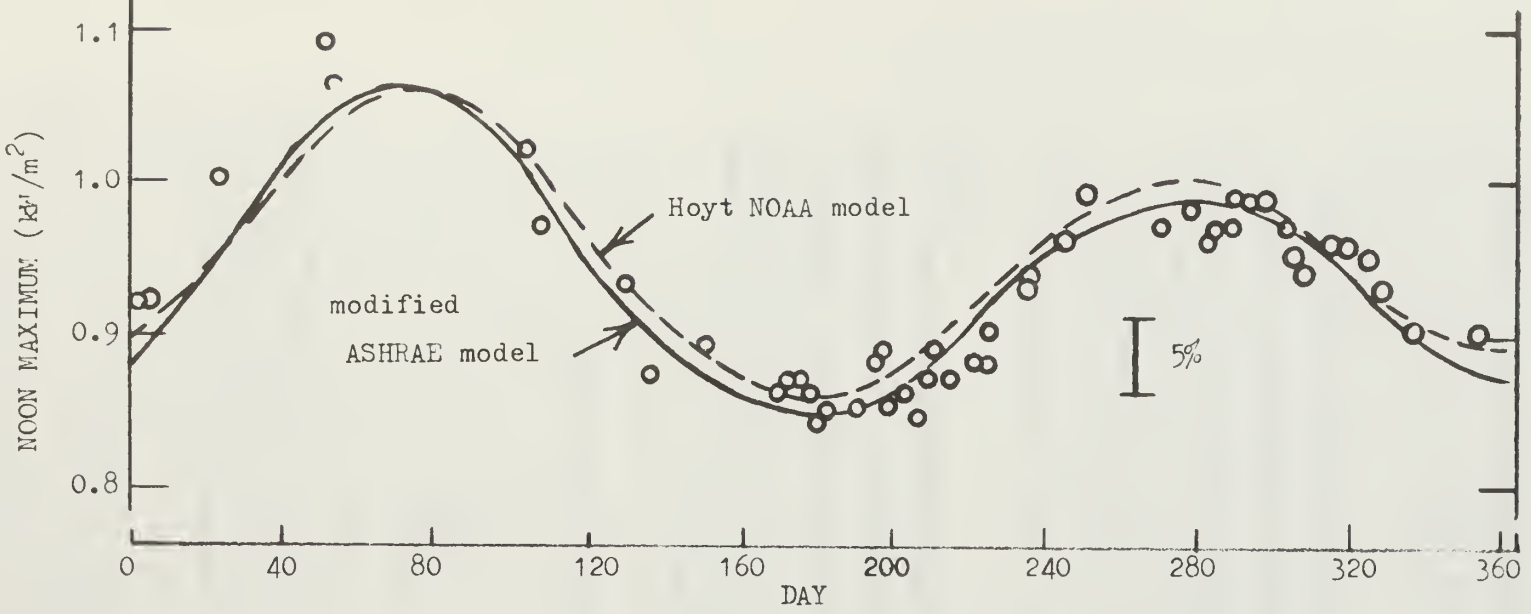
File Structure

The processed data from each day consists of day number, total energy density, day length, noon maximum intensity (if day was clear), intensity spectrum, half-hour average solar intensities, and a fault code (specifying lost or suspect data). The total energy is stored in 2 (8 bit) bytes and, thus, has a maximum resolution of 1 part in 512. All other non-integer quantities are rounded to integers and stored in a single byte in the file (maximum resolution 1 part in 256). The maximum loss of precision in this data due to rounding off is 0.5%.

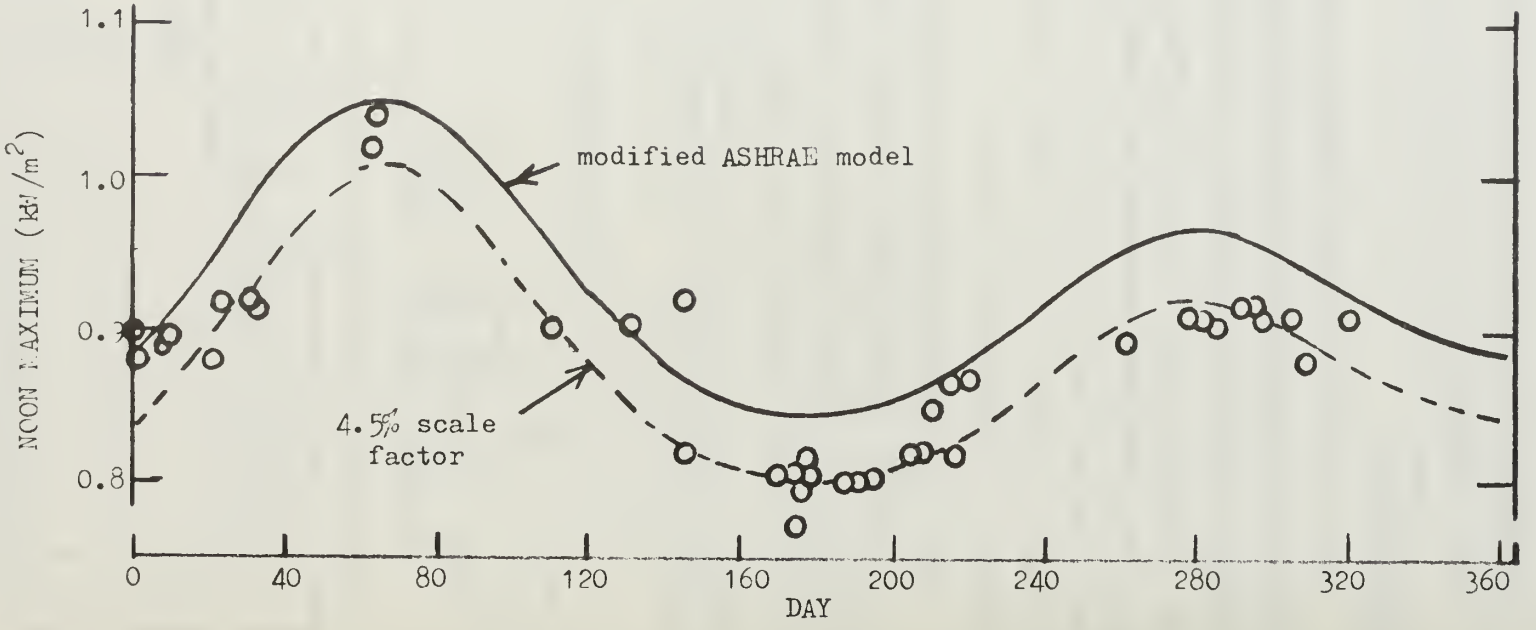
The data are stored on hard sectored, 5¼ inch magnetic diskettes using the North Star Disc Operating System (a popular microcomputer format). Each single-density diskette contains 3 station-years of solar data. This data has been used by Fowlkes Engineering as input to solar heating simulation models. Copies of these diskettes can be supplied at nominal cost for users wanting to implement their own simulation programs.

FILE STRUCTURE, 1 STATION - DATA - DAY





(a) Great FAlls data for 1978 showing two clear-day models with data



(b) Glendive data for 1978 illustrating use of scale factor

Figure 1. Comparison of clear day experimental and theoretical values

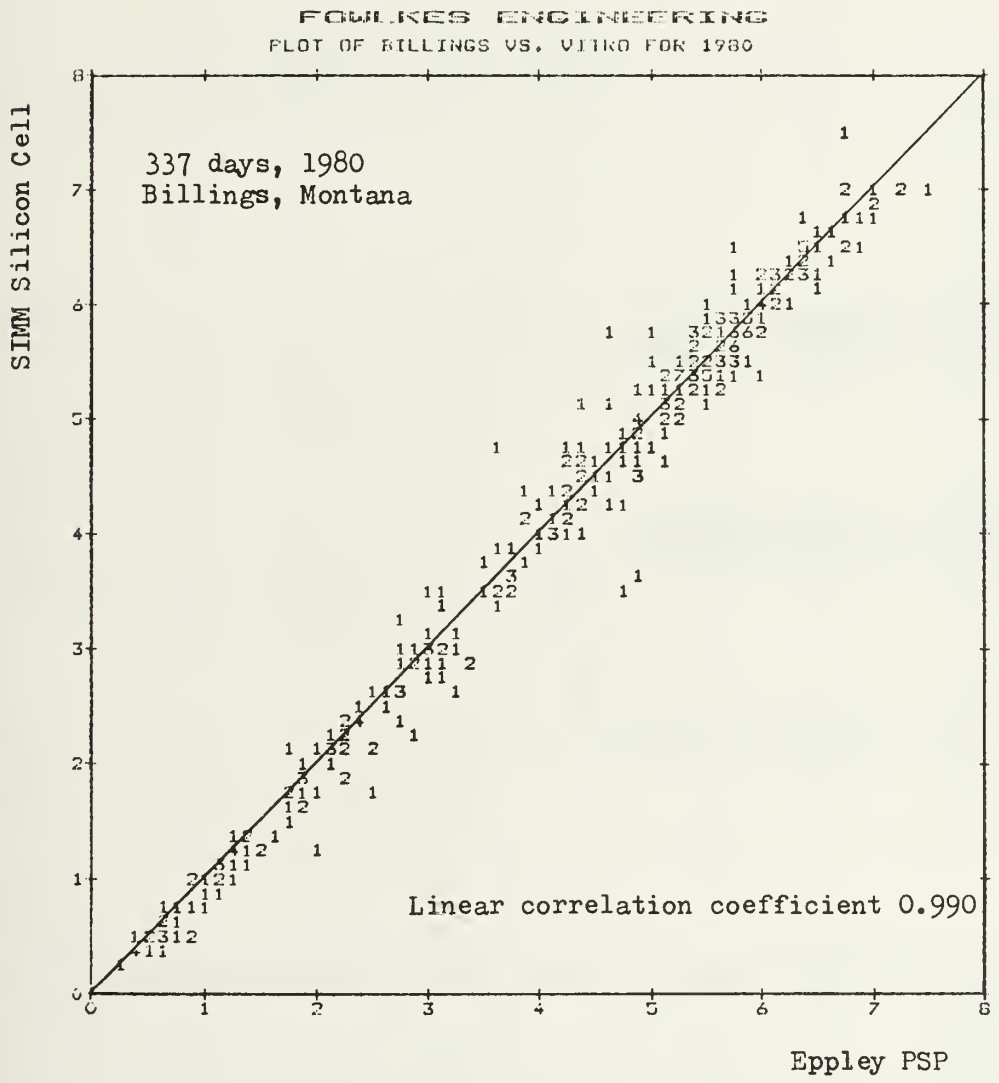


Figure 2. Scatter plot, daily totals, kWh-m^{-2}

Table 1. Daily Totals ($kW-m^{-2}$)
Billings, November, 1980

DAY	NSDN (PSP)	FOWLKES SIMM	NSDN LESS SIMM
1	2.59	2.66	-.07
2	2.18	2.13	.05
3	5.70	5.72	-.02
4	1.92	1.59	.33
5	6.07	6.16	-.09
6	1.51	1.25	.26
7	1.06	1.00	.06
8	4.41	4.78	-.37
9	1.06	1.06	.00
10	2.42	2.47	-.05
11	1.23	1.19	.04
12	0.65	0.63	.02
13	0.87	0.47	.40
14	5.27	5.06	.21
15	5.80	5.91	-.11
16	5.74	5.84	-.11
17	5.87	5.81	.06
18	2.92	2.84	.08
19	1.65	1.41	.25
20	3.76	3.84	-.08
21	1.82	1.84	-.03
22	0.58	0.50	.08
23	5.75	5.63	.13
24	2.28	2.22	.06
25	0.85	0.53	.31
26	5.17	4.63	.55
27	0.94	0.81	.13
28	5.80	5.31	.48
29	1.82	1.72	.11
30	0.39	0.38	.02
AVG	2.94	2.85	3.07%

Table 2. Monthly Average Daily Total ($kWh-m^{-2}$)

MONTH	NSDN (PSP)	FOWLKES SIMM
JAN	3.13	3.29
FEB	3.29	3.29
MAR	4.14	4.01
APR	5.23	5.18
MAY	4.77	4.74
JUN	4.84	4.82
JUL	5.25	5.15
AUG	4.75	4.73
SEP	4.80	4.72
OCT	*4.38	4.33
NOV	2.94	2.85
DEC	2.05	*1.88

*missing 8 to 10 days

Table 3. Bozeman Daily Totals ($kWh-m^{-2}$) November, 1980

DAY	KIPP	LI-COR	SIMM
1	2.80	2.84	2.72
2	1.95	1.94	1.88
3	1.01	0.99	0.93
4	2.04	2.07	1.96
7	0.42	0.44	0.39
8	4.21	4.22	4.13
9	1.39	1.39	1.31
10	1.40	1.32	1.30
11	0.54	0.55	0.53
12	1.14	1.15	1.12
13	5.67	5.62	5.44
14	*5.33	6.60	6.36
15	6.68	6.55	6.38
16	6.62	6.61	6.43
17	4.13	4.40	4.24
18	1.10	1.03	1.05
19	0.93	0.89	0.86
20	3.83	3.77	3.68
21	3.04	3.02	3.00
22	0.73	0.68	0.66
23	5.43	5.40	5.28
24	3.71	3.61	3.54
25	0.71	0.64	0.63
26	4.44	4.43	4.28
27	1.74	1.66	1.66
29	2.01	1.94	1.93
30	1.54	1.45	1.44
AVG	2.66	2.64	2.57

*Frost

RADIATION (kWh/M2) x 317 = RADIATION (BTU/ft^2)

Table 4. CLEAR DAY COMPARISONS

Station name	1977 * Clear days	1977 Deviation,% ** Orig.	1977 Deviation,% ** Adj.	1977 Class	1978 Clear days	1978 Deviation,% ** Orig.	1978 Deviation,% ** Adj.	1978 Class
Anaconda					21	4.0	3.4	II
Billings	20	5.2	2.06	I	56	4.7	3.3	I
Bozeman	27	4.1	2.8	I	58	4.1	2.8	I
Browning	34	8.5	2.5	II	38	5.1	3.4	I
Butte	25	7.4	2.2	II	15	5.1	2.9	I
Choteau					49	4.5	2.2	I
Colstrip	14	3.7	1.7	I	55	3.2	3.0	I
Dillon	46	8.0	6.1	III	56	5.9	4.1	II
Ennis					34	3.6	2.2	II
Fort Benton					33	4.9	1.8	II
Glasgow	58	9.1	2.3	II	65	7.2	3.1	II
Glendive	45	5.6	2.3	I	40	5.1	3.1	I
Great Falls	50	2.5	2.5	I	51	2.3	2.3	I
Hamilton	20	8.4	3.2	III	25	9.4	4.0	III
Harlowton	43	6.2	2.1	II	35	8.9	2.0	II
Havre	42	3.1	2.0	I	41	4.0	3.3	II
Helena	36	7.0	3.4	I	44	5.7	4.6	I
Jordan					55	10.2	3.5	III
Kalispell	35	3.3	3.01	I	42	5.3	5.1	II
Lewistown	36	6.8	2.5	I	34	8.2	2.3	III
Libby	28	2.1	2.5	I	34	5.7	3.6	II
Livingston					35	6.8	4.8	III
Miles City	45	5.0	1.7	II	41	3.5	3.5	I
Missoula	33	5.0	2.7	I	45	5.8	4.1	II
Plentywood					24	10.0	5.9	III
Polson	41	4.0	1.4	I	52	3.8	1.7	I
Red Lodge					45	9.6	4.3	III
Sidney					16	5.6	3.6	II
Thompson Falls					28	4.7	4.0	II
W. Yellowstone	27	11.1	3.2	III	46	11.1	5.6	III

* A "clear day" is a day that is clear for several hours around solar noon.

** Average absolute value of deviation for all clear days.

Table 4 (Continued)
1979 CLEAR DAY COMPARISONS

Station name *	Clear days	Deviation, %** Orig.	Adj.	Class
Anaconda	34	4.3	2.2	I
Billings	93	6.1	2.6	I
Bozeman	97	6.9	2.8	I
Browning	28	6.0	2.0	I
Butte	47	8.0	2.0	I
Choteau	74	3.6	3.6	I
Colstrip	20	8.6	4.7	II
Dillon	69	3.3	1.9	I
Ennis	69	2.6	2.5	I
Fort Benton	79	6.4	1.8	I
Glasgow	55	9.8	2.1	II
Glendive	58	4.1	2.0	I
Great Falls	98	3.0	2.1	I
Hamilton	72	9.5	3.2	II
Harlowton	60	7.7	1.4	I
Havre	54	4.3	2.7	I
Helena	64	5.5	2.6	II
Jordan	54	15.7	4.1	III
Kalispell	27	3.7	2.7	I
Lewistown	84	8.2	2.6	II
Libby	64	2.8	2.3	I
Livingston	27	5.1	2.0	I
Miles City	76	7.0	2.1	I
Missoula	69	5.7	2.3	I
Plentywood	39	7.1	4.3	II
Polson	43	3.6	2.0	I
Red Lodge	76	7.9	3.1	II
Sidney	64	3.0	2.3	I
Thompson Falls	19	4.2	3.0	II
West Yellowstone	60	11.3	2.8	II

* A "clear day" is a day that is clear for several hours around solar noon.

** Average absolute value of deviation for all clear days.

Table 4 (Continued)
1980 CLEAR DAY COMPARISONS

Station Name	*Clear Days	**Deviation % Orig.	Adj.	Class
Anaconda	27	5.9	1.7	II
Billings	69	10.0	2.1	I
Bozeman	56	5.9	1.9	I
Browning	25	6.8	1.3	I
Butte	46	7.6	2.2	I
Choteau	50	4.6	1.9	II
Colstrip	51	3.26	3.18	I
Dillon	49	2.7	2.5	I
Ennis	29	2.7	1.88	I
Fort Benton	61	5.7	1.5	II
Glasgow	66	2.8	1,7	II
Glendive	39	1.8	1.8	I
Great Falls	58	4.0	1.8	II
Hamilton	45	4.2	1.6	I
Harlowton	54	1.8	1.2	I
Havre	40	4.3	3.3	II
Helena	24	2.0	1.8	I
Jordan	77	13.0	2.3	II
Kalispell	29	2.0	1.6	I
Lewistown	50	1.4	1.4	I
Libby	30	3.1	1.6	II
Livingston	31	6.4	2.5	III
Miles City	79	4.4	1.9	II
Missoula	26	4.7	3.0	I
Plentywood	59	4.2	2.1	II
Polson	51	2.7	1.4	I
Red Lodge	48	7.1	3.1	II
Sidney	42	5.7	2.0	III
Thompson Falls	21	3.6	2.7	III
West Yellowstone	38	4.3	1.8	II

* A "clear day" is a day that is clear for several hours around solar noon.
** Average absolute value of deviation for all clear days.

APPENDIX IV: SIMPLIFIED F-CHART DESIGN PROCEDURE FOR ACTIVE SOLAR HEATING SYSTEMS

What is F-Chart?

F-chart is a graphical method for predicting the performance of active solar heating systems. It uses readily available information such as solar collector specifications, estimates of heating load, and weather data to calculate the fraction of the heating load, f, which solar energy would provide for a particular design. F-chart is therefore quite useful in the design process for sizing systems and estimating system economics and energy savings.

A complete discussion of the f-chart method including all necessary weather data for 100 U.S. and Canadian cities is given in Solar Heating Design by the f-Chart Method; Beckman, Klein and Duffie; Wiley, 1977. The method was developed by the Solar Energy Laboratory of the University of Wisconsin. It represents a correlation of the results of numerous system simulations using the computer program TRNSYS (Transient System Simulation), also developed at the University of Wisconsin. The method has been set up for hand calculation using a series of standard forms and tables. It has also been automated into the interactive computer program FCHART which is available from the University of Wisconsin Solar Energy Laboratory, Madison, Wisconsin, 53706. The simplified method presented in this Appendix is based entirely on this work.

F-chart can be used for predicting the performance of active domestic hot water, space heating, or combined systems. Extensions of the method for passive heating systems are under development at the University of Wisconsin but are not treated in this Appendix. F-chart is especially useful for design of domestic hot water systems because of the greater accuracy with which hot water heating loads may be estimated. It is most accurate when used on reasonably standard designs using standard amounts of thermal storage and having reasonable efficiency and heat losses. For such systems, the f-chart predictions have been found to agree well with actual field data. Methods have been developed to account for effects of non-standard collector fluid flowrate and thermal storage. These are described in the above book.

What is Simplified F-Chart?

The simplified f-chart method presented here attempts to reduce the amount of engineering calculations required for estimating system performance by using assumed values for certain parameters. Use of the solar radiation data in Section III of this manual also greatly simplifies the method, because solar radiation data is given there for the tilted plane of the collector. This eliminates the somewhat tedious calculation of tilted plane solar radiation from the horizontal plane solar radiation generally tabulated by the Weather Bureau. Such a calculation is required in the full f-chart method.

What Solar Systems May be Analyzed with Simplified F-Chart?

Simplified f-chart may be used to estimate the fraction by solar for domestic hot water, space heating, or combined active solar heating systems. Either liquid or air systems may be considered. The method is most accurate for flat plate collector systems of at least approximately known thermal specifications. It may be used for approximate analysis of evacuated tubular collector systems, site-built air collector systems for which only estimated collector thermal specifications are available or for systems utilizing complex control or thermal storage strategies. (These restrictions apply to the full f-chart method as well). Typical collector efficiency curves are included for use when test data is not available.

How Accurate is Simplified F-Chart?

The accuracy of any solar performance estimation method is limited primarily by the accuracy of the inputs; heating load and weather data. Heating loads may vary from estimated values by 25% or more, especially in the case of space heating loads which have been estimated from handbook data. Weather parameters may vary from year to year by 25% or more.

The accuracy of the simplified f-chart method itself, assuming perfectly accurate input, is probably better than 25% for any system and considerably better for domestic hot water systems of standard design. For those interested in improving this portion of the accuracy, the full f-chart method should be used for systems having at least one of the characteristics below:

1. The amount of thermal storage is not between 1.5 and 3 gallons of water (liquid systems) or 0.6 to 1 cubic feet of rock (air systems) per square foot of solar collector.
2. The air flow rate through each collector panel for air systems is not between 1 and 4 cubic feet of air per minute per square foot of solar collector.
3. The collector orientation is not within $\pm 15^{o}$ of true south.
4. The heat exchanger, if present, which transfers heat from the fluid heated in the solar collectors to the load is not of standard engineering design.

Such corrections are seldom warranted because heating load and weather data contain larger approximations.

How Does Simplified F-Chart Work?

Simplified f-chart will estimate monthly and yearly solar fraction and solar and backup heat rates by following the three steps below. All data is entered on the Worksheet shown in Figure 1. This Worksheet can be used as a master to reproduce working copies using an office copier. In general, there are three kinds of inputs to the method:

1. System parameters; constant thermal parameters of the system including solar collector efficiency factors, hot water usage, and building heat loss coefficient.
2. Collector area; also a system parameter but the one typically varied in the design process to determine optimum performance.
3. Weather data; average solar radiation on the tilted surface, heating degree days, and average temperature. These are tabulated in earlier sections of the manual.

And there are two kinds of output:

1. Solar fraction; the monthly and yearly fraction of the heating load provided by solar energy.
2. Solar and backup heat rates; monthly and yearly energy supplied from the sun and by backup to meet the total heating load.

Use is made of the metric system of units in this Appendix because the solar radiation data in this Manual is given in metric units. (A units conversion table is presented in Appendix V).

STEP 1: ESTIMATE SYSTEM PARAMETERS

There are five constant system parameters which must be estimated.

a. Heat Exchanger Factor (B)

A heat exchanger may be present in the system to transfer heat from the fluid heated in the solar collectors to the thermal storage. Choose B from the following table and enter it at the bottom of the Worksheet, Figure 1.

Situation	Heat Exchanger Factor (B)
No heat exchanger used	1
Heat exchanger used	0.9

Heat exchangers of non-standard engineering design should be treated using the full f-chart method for improved accuracy.

b. Solar Collector Heat Loss Factor (C)

The thermal performance of flat plate solar collectors is typically expressed by two factors. These are measured in a standard manner (ASHRAE 93-77) and reported in the thermal specifications section of the collector data sheets. The collector heat loss factor, C, is labelled "F_rU_L" on most data sheets, or given as the slope of the efficiency curve. C must be used in metric units in this method; $W/^oC\text{-}m^2$. If it is reported in english units, $BTUh/^oF\text{-}ft^2$, multiply it by 5.67.

If C cannot be determined from the collector data sheets, Figure 2 (for liquid collectors) or Figure 3 (for air collectors) should be used to determine C for the type of collector used. The value of the Collector Heat Loss Factor should be entered at the bottom of the Worksheet.

c. Solar Collector Glazing Factor (D)

The solar collector glazing factor, D, is the other standard thermal performance factor reported in the thermal specification section of collector data sheets. D is labelled $F_r\tau\alpha$ on most data sheets or given as the y-intercept of the efficiency curve. It is dimensionless. If D cannot be determined from the collector data sheets, Figure 2 (for liquid

collectors) or Figure 3 (for air collectors) should be used to determine D for the type of collector used. The Collector Glazing Factor should be entered at the bottom of the Worksheet.

d. Water Heating Load (Q_w)

The water heating load, Q_w, is the monthly energy required for heating domestic hot water. Q_w depends on hot water consumption, and hot and cold water supply temperatures. An estimate for Q_w should be taken from the following table:

Number in Family	Water Heating Load (Q_w)
2	205 kWh/month
4	380 kWh/month
6	560 kWh/month

(These figures assume 20 gal/capita-day for the first occupant, and 15 gal/capita-day for additional occupants, and temperature rise of 80°F. If more accurate figures are known they should be used. See the f-chart book for treatment of variable cold water supply temperature). If no solar water heating is included in the design, the value of Q_w should be set to zero. The estimated Water Heating Load, Q_w, should be entered at the bottom of the Worksheet.

e. Building Heat Loss Factor (L)

The building heat loss factor, L, represents the overall "UA" of the building, including infiltration. It is the most difficult of the system parameters to accurately determine. It is beyond the scope of this Manual to discuss the various methods available for the calculation of the building heat loss factor. If the reader is not familiar with such calculations, he should either consult an appropriate reference listed in a later Appendix or make a very approximate determination of L from the following table:

For Buildings Which Are	Multiply the Floor Area in Square Feet by This Factor to Generate an Estimate of L in kWh/°C-Day
Well insulated and sealed	0.0026
Moderately well insulated and sealed	0.0053
Poorly insulated and sealed	0.008

The value of the Building Heat Loss Factor, L, should be entered at the bottom of the Worksheet. If solar space heating is not being considered, this calculation may be eliminated.

EXAMPLE: A solar water and space heating system is being designed for a family of four in Billings. The collectors are liquid type and are double glazed with the absorber painted black. No data sheets are available for the collectors. A heat exchanger is used. No building heat loss factor is available but the house is well insulated and sealed and has 1800 ft^2 of living area. A tilt angle of 50° is selected.

The system parameters are:

B = .9 (heat exchanger is used)

C = 4.3 $w/°C-m^2$ (from Figure 2, collector type 2)

D = .6 (from Figure 2, collector type 2)

Q_w = 380 kWh/month (family of four)

L = 4.7 kWh/°C-day (1800 ft^2 x 0.0026; well insulated and sealed)

STEP 2: CHOOSE COLLECTOR AREA (A)

The collector area is the parameter most often chosen for system optimization. Because factory built solar collectors are expensive, the number of collectors significantly affects system costs and hence payback. Also, diminishing returns will set in; as collectors are added to the system, the incremental increase in solar fraction will taper off.

If the number of solar collectors is not yet fixed, it is recommended that an initial design value of A be calculated from the number of collectors given in the following table:

System Type	Family Size	Number of Collectors	Typical Collector Area (m^2)
Water Heating	2	2	3 - 8
	4	3	
	6	4	
Space heating or combined	-	10	20 - 50

It will be necessary to determine the area of each solar collector from the collector data sheets, in square meters. If the collector area is given in square feet, divide by 10.76. Enter the Collector Area, (A), at the bottom of the Worksheet. The system performance may then be estimated using Step 3.

Because the values of the correlation parameters X and Y (heating load factor and solar availability factor) are proportional to A, the monthly performance for other values of collector area may be easily determined without the somewhat tedious process of STEPS 1, 2, and 3.

A collector tilt of about 60° is normally used for winter collection of solar radiation for space heating in Montana. For domestic water heating a tilt of 45 to 50° would be typical. Enter Collector Tilt on Worksheet.

EXAMPLE: Collector data sheets were not available, but the aperture area of a single collector is measured to be 18 ft^2. The initial design collector area will be:

$$A = (15 \text{ collectors} \cdot 18 \text{ ft}^2/\text{collector})/10.76 \text{ m}^2/\text{ft}^2 = 25 \text{ m}^2$$

STEP 3: CALCULATION PROCEDURE

Calculation of monthly heating load factors, X, solar availability factors, Y, monthly and yearly solar fractions, and heat rates should be done using the Worksheet, Figure 1. Values of A, B, C, D, L, Q_w and tilt determined in STEPS 1 and 2 should now be entered at the bottom of the Worksheet. Then:

a. Copy the value of Q_w from the bottom of the worksheet into Column (2) for all months. (If solar water heating is not included in the design, all values Q_w in column (2) should be zero.)

b. Copy the monthly heating degree days (^{o}C) for the site (from the climatological data in Section VIII of the Manual) into column (3). (Since the climatological data is given in both Celsius and Fahrenheit, care should be taken to use degree days in degrees Celsius.)

c. Calculate the space heating load, Q_s, by multiplying the values in column (3) by the building heat loss factor, L, and entering the result in column (4). (If solar space heating is not included in the design, all values of Q_s in column (4) should be zero.)

d. Calculate the total heating load, Q, by adding columns (2) and (4) and entering the result in column (5). Sum the values in column (5) to obtain the yearly heating load and enter the result in block (15).

e. Copy the values of daily average temperature for the site, T, from the climatological data in Section VIII of the Manual into column (6). (The climatological data is given in both Celsius and Fahrenheit and care should be taken to use daily average temperature in degrees Celsius.)

f. Calculate the reference temperature difference by subtracting the values of T in column (6) from 100 and enter the results in column (7).

g. Calculate the monthly heating load factor, X, by multiplying the value of A·B·C by the value in column (7) and by 0.72. Then divide by the value in column (5) and enter the results in column (8).

h. Copy the values of daily average solar radiation for the site, S, from Overall Averages, Section III, of the Manual into column (9).

i. Copy the collector tilt correction factors for the desired tilt angle from Section IV of the Manual into column (10).

j. Calculate the solar availability factor, Y, by multiplying the value for A·B·D by values in columns (9) and (10) and by 30. Then divide by the value in column (5) and enter the results in column (11).

k. Using the f-chart correlations shown in Figure 4, determine values of the monthly solar fraction, f, and enter in column (12). This can be done by plotting the point (X,Y) onto the correct f-chart (liquid or air system) and interpolating the values of f from the curves immediately above and below the point (X,Y). Because this method is an approximate one for many reasons, a guesstimated interopolation is completely adequate. The values should be entered into column (12). This value, f, is the fraction of the total heating load which the solar system is contributing.

l. Calculate the monthly solar energy delivered to the heating load by multiplying the values in column (5) by the values in column (12) and entering the results in column (13). Sum this column to yield the yearly solar energy delivered to the heating load and enter in block (16).

m. Calculate the monthly backup energy needed by subtracting the values in (13) from the values in column (5) and entering the results in column (14). Subtract the value in block (16) from the value in block (15) to yield the yearly backup energy required, and enter that result in block (17).

n. Calculate the yearly solar fraction by dividing the value in block (16) by the value in block (15). This is the fraction of the yearly total heating load which the solar heating system is designed to contribute. (The monthly solar fractions cannot be combined directly to yield a yearly solar fraction because of the nonlinearity of the f-chart correlations.)

EXAMPLE: A sample completed worksheet for the example system is shown in Figure 5. The annual solar fraction for this system was 45%.

Where Can I Go From Here?

The predicted solar fraction and solar and backup heat rates calculated by the simplified f-chart method can be considered an end in themselves for some cases. If the solar system design is to be optimized, however, some economic analysis may be desired to estimate the payback for that given collector area. Appendix II of this Manual presents one example of such a calculation. The collector area (number of collectors) can then be modified up or down, and the system performance and economics recalculated to determine an optimum area. (The considerable uncertainty of future fuel prices, however, make such an optimization only an approximation or best guess).

The f-chart correlation parameters X and Y are proportional to collector area. The solar fractions and heat rates from the Worksheet can be recalculated for new values of collector area without having to repeat the entire calculation. To recalculate the solar fraction for a new area multiply all values of X which were calculated using the old area (column 8) by ($\frac{\text{new area}}{\text{old area}}$). Repeat for all values of Y (column 11). These corrected values of X and Y can then be used to estimate new values of f using the f-charts, and hence heat rates. In this manner, an optimal collector area for a given set of economic assumptions may be relatively quickly determined.

Rules of Thumb and Recommendations

Table 1 lists nominal values of flow rate and storage size for active air and liquid solar systems. The simplified f-chart design procedure assumes that the system parameters are within the range of values shown in Table 1. For these systems, the simplified f-chart will produce a reasonable prediction of the solar heat delivered by the system.

An approximation of the overall solar system conversion efficiency allows a quick estimate of the solar heat available. The rules of thumb for conversion efficiency are: (a) BEST = 35 to 45%, (b) AVERAGE = 20 to 30%, (c) POOR = 0 to 15%. The heat delivered by the system during the winter is calculated using the following equation:

Solar heat/day = (Collector area) x (Efficiency/100) x (Average solar radiation)

To use this equation, look up the monthly average, daily solar radiation from the appropriate Solar Data Table for the location of the project. Estimate the category of the collector to be used; the collector efficiency curves given in this Manual may help. For example, the BEST category might be a well insulated, double glazed, selective surface collector. (Note that a vertical passive solar wall with an effective movable insulation system would also be classified as BEST.) If the collector had inadequate flow storage or insulation or was leaky, it might be classified as POOR.

Solar domestic hot water systems will produce about 300 to 600 kWh per square meter of collector area per year (100,000 to 200,000 BTU/ft^2-yr). Collector areas for residences are usually between 4 and 6 m^2 (40 to 60 ft^2). Typical systems will supply about 50% of the annual energy required to heat the domestic water. "Hot Water from the Sun" (see References, Appendix VI) is an excellent book on domestic hot water solar system performance and economics for the lay person.

TABLE 1
DESIGN RECOMMENDATIONS FOR ACTIVE SOLAR SPACE HEATING SYSTEMS IN MONTANA*

	LIQUID SYSTEMS	AIR SYSTEMS
Collector Slope and Orientation	Tilted up 50 to 90° from horizontal, facing true south ± 15°	
**Flow rate	0.015 $l/s\text{-}m^2$ (0.022 gpm/ft^2)	5 to 20 $l/s\text{-}m^2$ (1 to 4 cfm/ft^2)
Storage media	Water tank	Pebble bin, 1 to 3 cm. diameter (0.5 to 1.5 in.)
Volume	50 to 100 l/m^2 (1 to 2 gal/ft^2)	0.15 to 0.35 m^3/m^2 (0.5 to 1.15 ft^3/ft^2
Cautions	Design & install collectors to prevent any possibility of freezing.	Carefully seal ducts, collectors & storage to prevent leaks. Test final system for leaks.

* Adapted from Solar Heating Design by the f-Chart Method, Beckman, Klein and Duffy, John Wiley and Sons.
**per unit collector area

SIMPLIFIED f-CHART WORK SHEET

(1) MONTH	(2) WATER HEATING LOAD	(3) HEATING DEGREE DAYS	(4) SPACE HEATING LOAD	(5) TOTAL HEATING LOAD	(6) AVERAGE TEMP	(7) REFERENCE TEMP DIFF	(8) HEATING LOAD FACTOR	(9) DAILY AVG SOLAR RADIATION	(10) TILT CORRECTION FACTOR	(11) SOLAR AVAIL FACTOR	(12) SOLAR FRACTION	(13) SOLAR ENERGY	(14) BACK-UP ENERGY
	$\frac{kWh}{month}$	^{o}C-days	$\frac{kWh}{month}$	$\frac{kWh}{month}$	^{o}C	^{o}C	X	$\frac{kWh}{m^2\text{-day}}$		Y		$\frac{kWh}{month}$	$\frac{kWh}{month}$
	Q_w	DD	$Q_s = L \cdot (3)$	$Q = (2) + (4)$	T	$100 - (6)$	$\frac{0.72 \cdot (7) ABC}{(5)}$	S		$\frac{30 \cdot ABD \cdot (9)(10)}{(5)}$	f	$(5) \cdot (12)$	$(5) - (13)$
JAN													
FEB													
MAR													
APR													
MAY													
JUN													
JUL													
AUG													
SEP													
OCT													
NOV													
DEC													
YEARLY TOTALS				$\frac{kWh/year}{(15)}$						Annual Solar Fraction = _____		$\frac{kWh/year}{(16)}$	$\frac{kWh/year}{(17)}$

Q_w = Water Heating Load = _____ $\frac{kWh}{month}$

A = Collector Area = _____ m^2

B = Heat Exchange Factor = _____

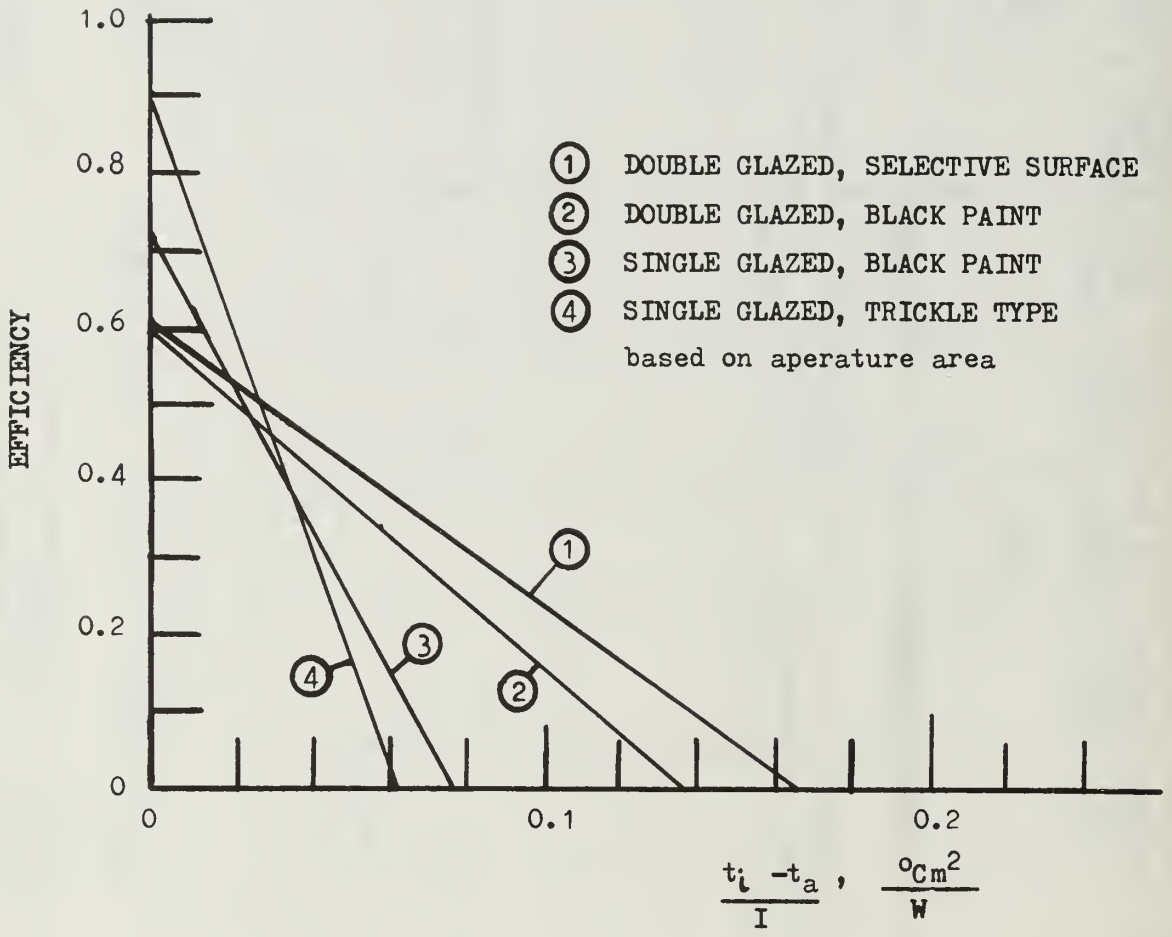
C = Collector Loss Factor = _____ $\frac{W}{^{o}C\text{-}m^2}$

D = Collector Glazing Factor = _____

L = Building Heat Loss Factor = _____ $\frac{kWh}{^{o}C\text{-day}}$

Collector Tilt = _____ degrees

Figure 2
TYPICAL LIQUID COLLECTOR PERFORMANCE CURVES

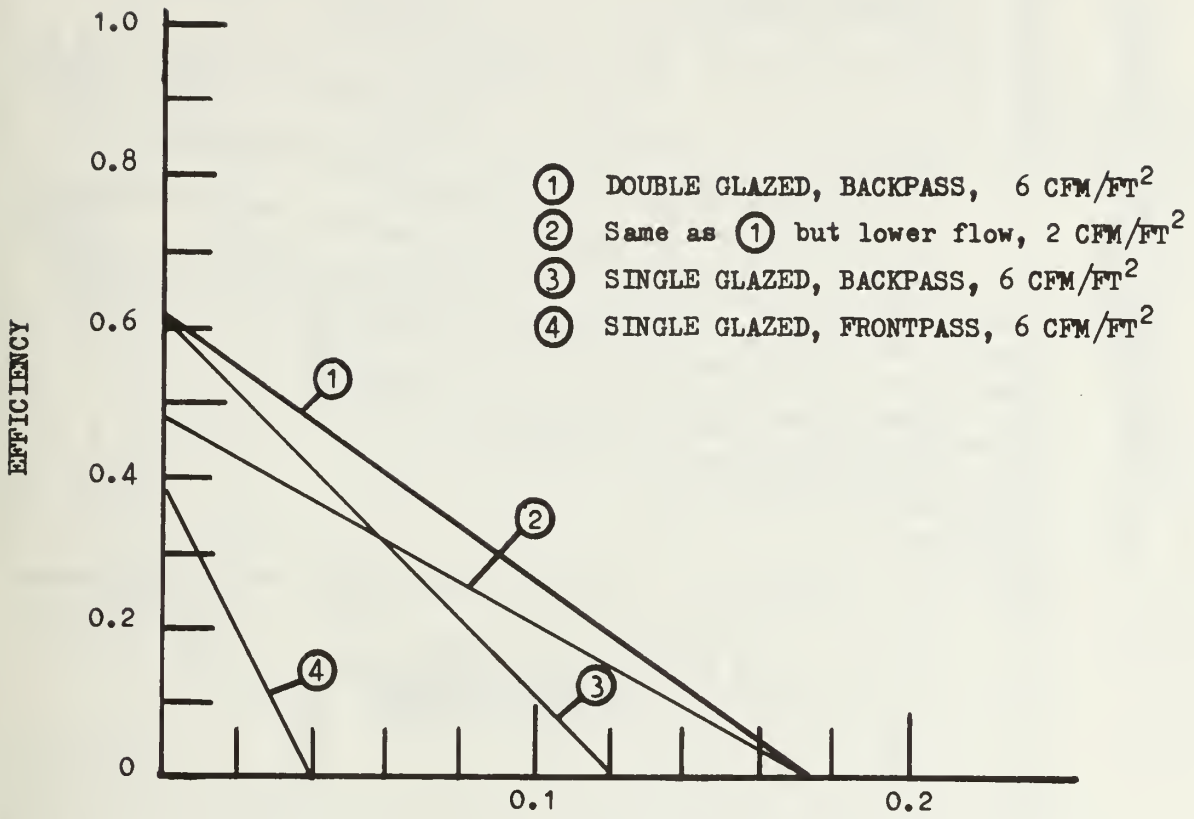


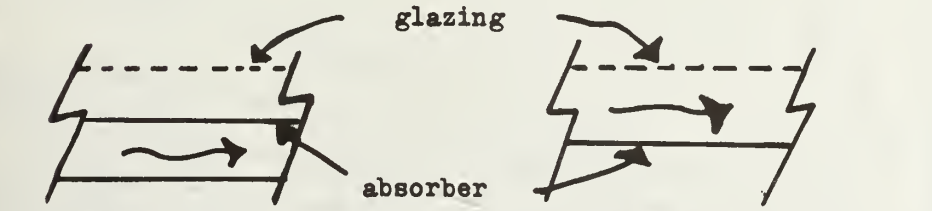
TYPE	D^* $F_R(\tau\alpha)$	C^{**} $F_R U_L$ $\frac{W}{^oC\text{-}m^2}$	C $\frac{Btu}{^oF\text{-}ft^2}$
1	0.6	3.5	0.61
2	0.6	4.3	0.75
3	0.73	9.1	1.60
4	0.90	13.8	2.42

* Y-intercept

** slope = Y-intercept/X-intercept
enter these values on worksheet

Figure 3
TYPICAL AIR COLLECTOR PERFORMANCE CURVES

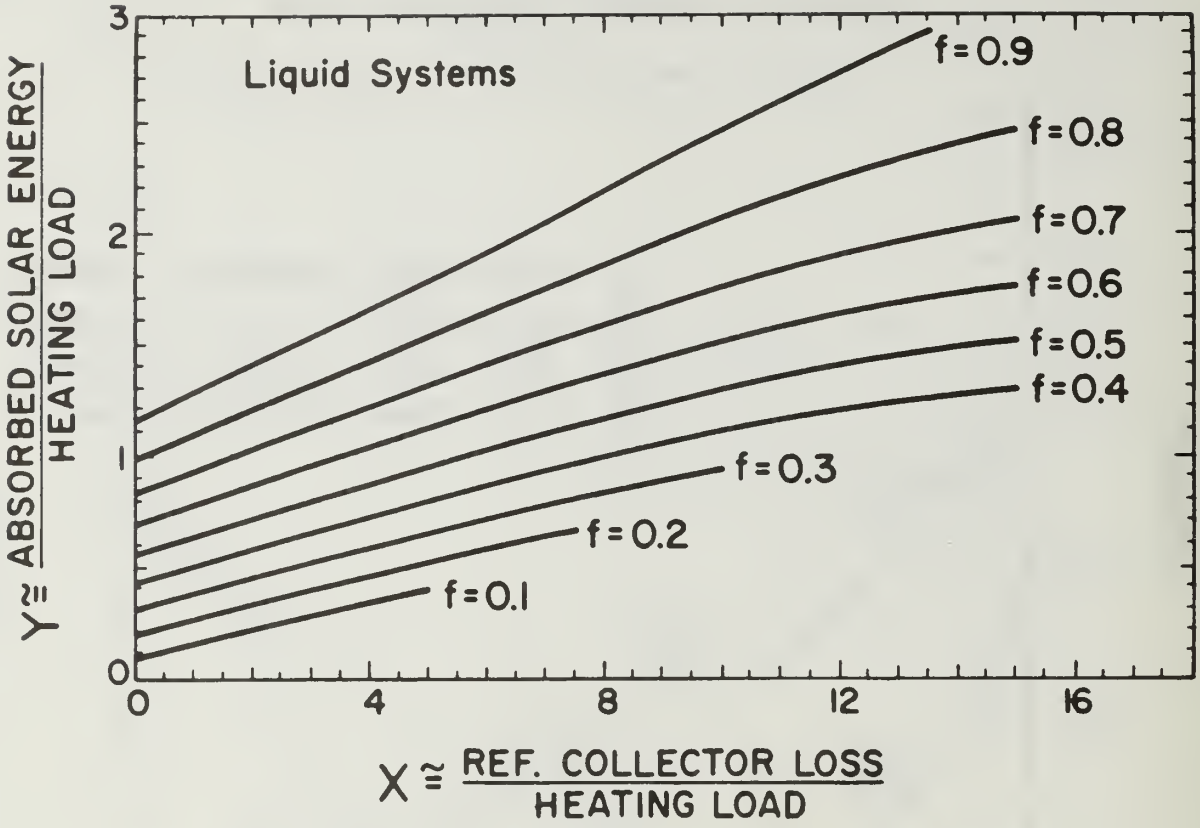




backpass, air flow under absorber

frontpass, air flow between absorber and glazing

TYPE	D $F_R(\tau\alpha)$	C $F_R U_L$, $\frac{W}{^oC-m^2}$	C $\frac{Btu}{^oF-ft^2}$
1	0.6	3.5	0.61
2	0.48	2.8	0.49
3	0.6	5.0	0.88
4	0.4	10.0	1.76



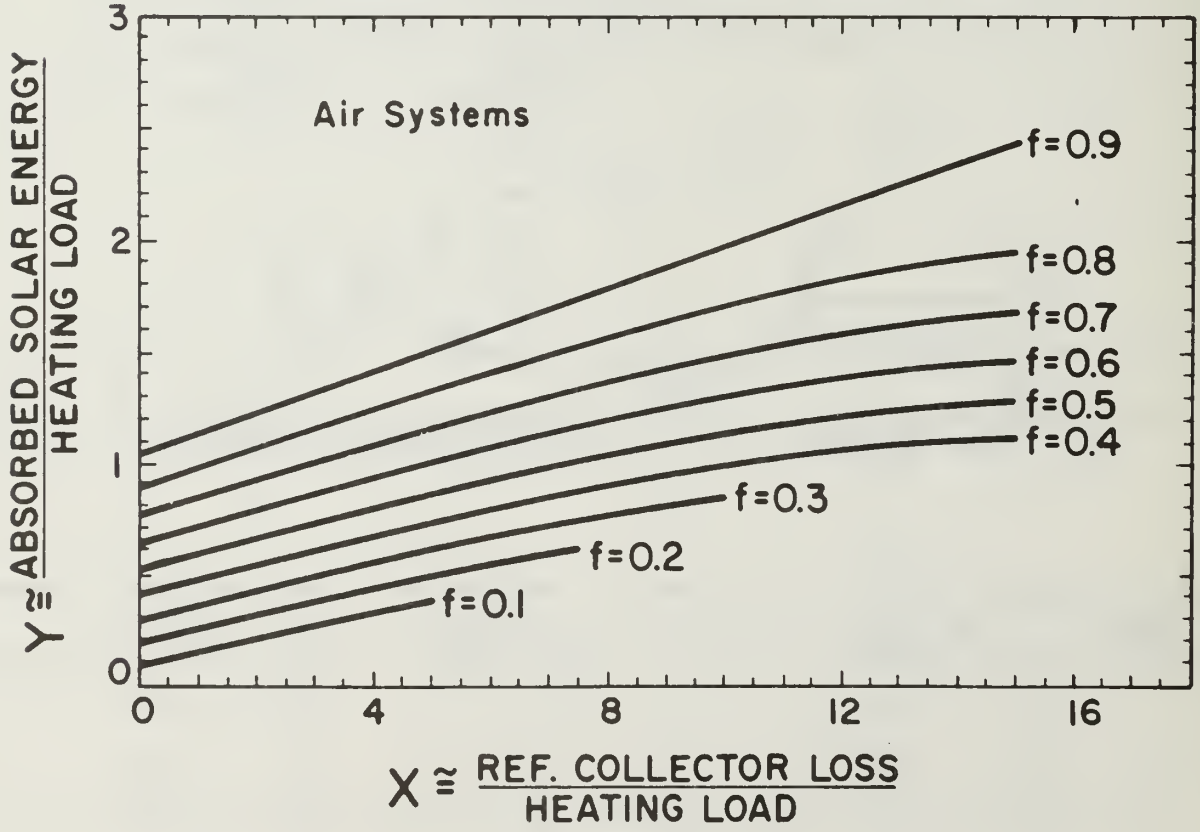


Figure 4: f-Chart Correlations

Figure 5: Sample Worksheet for Billings Example

SIMPLIFIED f-CHART WORK SHEET

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
MONTH	WATER HEATING LOAD	HEATING DEGREE DAYS	SPACE HEATING LOAD	TOTAL HEATING LOAD	AVERAGE TEMP	REFERENCE TEMP DIFF	HEATING LOAD FACTOR	DAILY AVG SOLAR RADIATION	TILT CORRECTION FACTOR	SOLAR AVAIL FACTOR	SOLAR FRACTION	SOLAR ENERGY	BACK-UP ENERGY
	kWh/month	°C-days	kWh/month	kWh/month	°C	°C	X	kWh/m²-day		Y		kWh/month	kWh/month
	Q_w	DD	$Q_s = L \cdot (3)$	$Q = (2)+(4)$	T	100−(6)	$\frac{0.72 \cdot (7)ABC}{(5)}$	S		$\frac{30 \cdot ABD \cdot (9)(10)}{(5)}$	f	(5)·(12)	(5)−(13)
JAN	380	720	3413	3793	-4.9	104.9	1.93	3.3	.97	.39	.28	1062	2731
FEB	380	548	2598	2978	-1.3	101.3	2.37	3.8	.99	.51	.3	893	2085
MAR	380	518	2455	2835	1.6	98.4	2.42	4.4	1.02	.64	.39	1106	1729
APR	380	301	1427	1807	8.3	91.7	3.54	4.6	1.06	1.1	.65	1175	632
MAY	380	160	758	1138	13.4	86.6	5.30	4.2	1.08	1.6	.85	967	170
JUN	380	67	318	698	17.3	82.7	8.25	4.7	1.10	3.0	1.00	698	0
JUL	380	6	28	408	21.9	78.1	13.3	4.8	1.08	5.1	1.06	408	0
AUG	380	12	57	437	20.8	79.2	12.6	4.8	1.06	4.7	1.00	437	0
SEP	380	122	578	958	15.1	74.9	5.45	5.2	1.02	2.2	.92	881	77
OCT	380	263	1247	1627	9.8	91.2	3.90	4.6	.99	1.1	.65	1058	569
NOV	380	476	2256	2636	2.4	97.6	2.58	3.5	.97	.52	.30	791	1845
DEC	380	640	3034	3414	-2.3	102.3	2.09	2.7	.96	.31	.20	683	2731
YEARLY TOTALS				22,729 kWh/year (15)								10160 kWh/year (16)	12569 kWh/year (17)

Annual Solar Fraction = 45%

Q_w = Water Heating Load = 380 kWh/month

A = Collector Area = 25 m²

B = Heat Exchange Factor = .9

C = Collector Loss Factor = 4.3 W/°C-m²

D = Collector Glazing Factor = .6

L = Building Heat Loss Factor = 4.74 kWh/°C-day

Collector Tilt = 50° degrees

APPENDIX V : CONVERSION IDENTITIES

LENGTH m,
1 meter = 3.2808 feet
1 meter = 39.3701 inches
1 km = 0.62137 miles
1 ft/min = 0.00508 m/s
1 mile/h = 0.44704 m/s
1 km/h = 0.277778 m/s

TEMPERATURE:
$t^{\circ} F = (1.8 \times T^{\circ} C) + 32$
$T^{\circ} C = (t^{\circ} F - 32) / 1.8$

MASS kg,
1 lb = 0.45359237 kg
1 oz = 28.3495 g
1 lb/ft^3 = 16.0185 kg/m^3
1 lb/h = 0.00012599 kg/s

ENERGY
1 kWh = 3410.08 Btu
1 kWh = 3600 kJ
1 Btu = 2.928×10^{-4} kWh
1 Btu = 1.0548 kJ
1 Btu = 0.251996 kcal
1 Btu = 10^{-5} therm
1 Btu = 10^{-15} quad

POWER
1 kW = 3414.43 Btu/h
1 kW = 56.8253 Btu/min
1 kW = 238.662 cal/sec
1 Btu/h = 2.931×10^{-4} kW
1 Btu/h = 0.01667 Btu/min
1 Btu/h = 0.0700 cal/sec
1 Btu/h = 3.9275×10^{-4} hp

AREA m^2,
1 m^2 = 10.7639 ft^2
1 m^2 = 1550 in^2
1 km^2 = 0.3860 $mile^2$
1 km^2 = 247.105 acres

VOLUME m^3,
1 ft^3 = 28.3168 liters
1 U.S.gal = 3.78544 liters
1 ft^3/lb = 0.062428 m^3/kg
1 cfm = 0.471947 liter/s
1 U.S. gpm = 0.0630907 liter/s

FORCE newton N,
1 lbf = 4.44822 N
1 psi = 6.89476 kPA
1 in H_2O = 249.089 Pa
1 atm = 101.325 kPa

ENERGY DENSITY
1 kWh/m^2 = 316.815 Btu/ft^2
1 kWh/m^2 = 3600 kJ/m^2
1 kWh/m^2 = 360 J/cm^2
1 kWh/m^2 = 85.933 cal/cm^2 (langley)
1 Btu/ft^2 = 3.1517×10^{-3} kWh/m^2
1 Btu/ft^2 = 11.3538 kJ/m^2
1 Btu/ft^2 = 1.13538 J/cm^2
1 Btu/ft^2 = 0.27125 cal/cm^2 (langley)

POWER DENSITY
1 kW/m^2 = 317.21 Btu/ft^2-h
1 kW/m^2 = 3600 kJ/m^2-h
1 kW/m^2 = 0.1 W/cm^2
1 kW/m^2 = 0.23901 langley/sec
1 kW/m^2 = 14.3406 langley/sec
1 Btu/ft^2-h = 3.1524 W/m^2
1 Btu/ft^2-h = 11,348 kJ/m^2-h
1 Btu/ft^2-h = 3.1524×10^{-4} W/cm^2
1 Btu/ft^2-h = 7.5347×10^{-5} langley/sec
1 Btu/ft^2-h = 4.5208×10^{-3} langley/min

The following prefixes are recommended for use with SI units:

tera T 10^{12}, giga G 10^{9}

mega M 10^{6}, kilo k 10^{3}

milli m 10^{-3}, micro 10^{-6}

nano n 10^{-9}, pico p 10^{-12}

SOME PROPERTIES IN SI UNITS

Density (kg/m^3)

Copper	8795
Steel	7850
Aluminum	2675
Glass, standard	2515
Concrete, typical, building	2400
Water, 4° C	1000
Ice, -1° C	918
Gypsum plaster, dry, 23° C	881
Oak, 14% wet	770
Pine, 15% wet	570
Pine fiberboard, 24°C	256
Asbestos cement, sheet, 30° C	150
Cork board, dry, 18° C	144
Ebonite, expanded, 10° C	64
Mineral wool, batts, -2°C	32
Polyurethane, foam, rigid	24
Polystyrene, expanded, 10° C	16
Air, p_o, 20° C	1.204

Heat of vaporization (kJ/kg)

Water, 20° C	2454.0
Water, 100° C	2257.0

Thermal conductivity (W/m° C)

Copper	385
Aluminum	211
Steel	47.6
Ice, -1° C	2.26
Concrete, typical, building	1.73
Glass, standard	1.05
Water, 20° C	0.596
Asbestos cement, sheet, 30° C	0.319
Gypsum plaster, dry, 23°C	1.170
Oak, 14% wet	0.160
Pine, 15% wet	0.138
Pine fiberboard, 24° C	0.051
Cork board, dry, 18° C	0.041
Mineral wool, batts, -2° C	0.034
Polystyrene, expanded, 10° C	0.034
Ebonite, expanded, 10°C	0.030
Air, p_o, 20° C	0.026
Polyurethane, foam, rigid	0.024

Specific heat (kJ/kg° C)

Water, 20° C, p_o	4.19
Ice, -21° C to -1° C	2.10
Steam (c_p), 100° C, p_o	1.95
Air (c_p), 20° C, p_o	1.012
Concrete, 18° C	0.837

Standard gravity g_o: $g_o = 9.80665$ m/s

Gas constants:

$R_u = 8314.4$ J/kmol K universal

$R_a = 287.045$ J/kg K air

Stefan-Boltzmann constant:

$$\sigma = 5.6697 \times 10^{-8} \text{ W/m}^2 \text{ K}^4$$

APPENDIX VI: REFERENCES

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